

MBTA REVERSE COMMUTING STUDY



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Staff for the Massachusetts Bay Transportation Authority

MBTA REVERSE COMMUTING STUDY

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EXECUTIVE SUMMARY

Section 343 of the Fiscal Year 2000 budget passed by the Massachusetts General Court in November 1999 directed the Massachusetts Bay Transportation Authority (MBTA) to prepare a study on the feasibility of providing additional commuter rail and connecting bus transportation services to facilitate reverse commuting. This report presents the results of that study, which was conducted for the MBTA by the Central Transportation Planning Staff (CTPS).

Context of the Reverse Commuting Issue

Providing transportation for reverse commuters is only one element of the overall problem of linking employment locations with the homes of the workers employed at those locations. Advocates of expanded reverse commuting service envision it as a means of increasing the labor supply for suburban work sites while reducing traffic congestion problems often associated with these sites. Experience to date, however, indicates that reverse commuting transit services from Boston, whether by rail or bus, will make negligible contributions toward either of these goals.

Suitability of Commuter Rail for Reverse Commuting

For many reasons, the MBTA commuter rail network is not well suited for providing reverse commuting service. At the Boston end, most residential areas are beyond walking distance from commuter rail stations, requiring use of one or more connecting services for access. At the suburban end, most major work sites are beyond walking distance of stations, requiring provision of connecting van or bus service. Local Transportation Management Associations (TMAs) or individual employers are better suited than the MBTA for providing suburban connections.

At present, schedules of outbound A.M. peak trains are determined largely by the requirements for cycling equipment efficiently between inbound trips. Likewise, inbound P.M. peak schedules are dictated largely by the needs of outbound service. Consequently, even if a major employment site is close to a rail station, it may be impossible to offer service that includes convenient arrival and departure times for large numbers of workers.

Constraints on Expansion of Reverse Commuting Service

The existing commuter rail fleet is heavily utilized during peak commuting hours. In most cases, times when train sets would be available to run new reverse commuting trips would not coincide with times of greatest potential demand for such service. Alternatively, revising schedules to allow operation of reverse commuting trips at more useful times would force some peak-direction trips to be changed to less convenient times than the present ones.

If additional train sets were acquired specifically for reverse commuting service, they would be underutilized, because load factors in such service would be low. Schedules would not allow these sets to also be used to provide new peak-direction trains at times of heavy demand. In addition, lack of storage capacity during times of day when these train sets were not being run could pose a problem, especially on South Side lines.

Aside from equipment constraints, potential schedules are also constrained by long segments of single track on most lines that restrict locations where inbound and outbound trains can meet. Coordination with freight train operations would also present some difficulties, especially on the Framingham/Worcester Line and on the outer segments of the Fitchburg and Haverhill/Reading lines.

Potential Demand for Enhanced Commuter Rail Reverse Commuting Service

Historically, the cities and towns to which commuter rail reverse-commuting service would be most feasible from an operations standpoint have not provided jobs for a large percentage of the Boston workforce, nor have they drawn large percentages of their workers from Boston. This is more a result of distance and of other opportunities closer to Boston than of a lack of adequate public transportation; Boston residents who drive to work do not go to distant suburbs in large numbers either.

The most detailed figures on work locations of Boston residents available at this writing are those from the 1990 U.S. Census Journey-to-Work reports. Figures from the 2000 Census will not be available until 2002. Figures on total employment by city and town from the Massachusetts Division of Employment and Training (DET) indicate that despite substantial growth in total suburban employment, the proportional distribution of workplace locations of Boston residents would not have changed significantly since 1990. Therefore, use of 1990 figures in this study is still reasonable.

In 1990, 83.4% of employed Boston residents worked either in Boston or in one of the 10 surrounding municipalities with rapid transit or light rail service. Only 10.6% worked in cities or towns now served directly by commuter rail but not rapid transit or light rail. On average, only 3.2% of the workers employed in those cities and towns lived in Boston. In absolute terms, these municipalities were the work locations of 29,200 Boston residents out of 276,300 who worked anywhere in 1990.

Only the top 10 cities and towns among these attracted more than 1,000 workers each from Boston, and they accounted for 64% of the 29,200 jobs. The top 10 were Waltham, Dedham, Norwood, Needham, Wellesley, Woburn, Lynn, Chelsea, Framingham, and Canton. By Spring 2000, most of these 10 were served by at least three outbound A.M. peak and three inbound P.M. peak commuter rail trains. Nevertheless, at that time, the number of Boston residents using commuter rail to travel to work in these cities and towns averaged only 63 each per day, or a mode

share of under 3.5%. Nine of the 10 are within 15 rail miles of downtown Boston; Framingham station is 21.4 miles from South Station.

Enhanced commuter rail would at best attract only a portion of the reverse commuters going to any given location from Boston, and most of them would have other means available for making the same trips. A very optimistic estimate indicates that if almost all commuter rail stations in the system were served by at least three outbound A.M. peak and three inbound P.M. peak trips, these trains would capture 3,770 work trips a day from Boston under current conditions. This would include about 1,510 riders who are already using commuter rail, and about 1,130 who would otherwise use express buses or feeder bus service from rapid transit. Another 1,130 would be diverted from autos. In addition to the 3,770 riders who would make the trips anyway, at most about 360 others would be attracted to make trips by commuter rail that they would not otherwise have made. This does not mean that all 360 would otherwise have been unemployed; many if not most of them would only be changing work locations. For reasons discussed in appendix B, the number of new riders from origins other than Boston who would be attracted by improved reverse commuting service would be negligible, as would the number of new non-work trips served by these improvements.

Population and employment projections for the next 20 years indicate that compared with 1990 the number of jobs within the city of Boston alone will have grown more slowly than the average for the entire Eastern Mass. Regional Planning Project (EMRPP) area (23.0% versus 27.0%). The Boston employment increase will, however, be 2.3 times as rapid as the Boston population growth (9.9%). Therefore, unless the kinds of jobs available in the suburbs are substantially more attractive than those available in Boston, there will be little reason for Boston residents to work in distant locations.

For almost all commuters with autos available, driving from a home in Boston to a suburban work location would be faster than taking commuter rail. Driving offers a one-vehicle ride from origin to destination, with full flexibility in departure times. Reverse-commuters travel in the opposite direction from peak highway traffic, and most have ample free parking provided at their work locations. Transit riders have the ability to read or work while traveling, which auto drivers do not, but this advantage for transit is negated to the extent that longer travel times take away from time that could otherwise be spent productively at home or at the work location. For these reasons, actual diversions of auto users to commuter rail reverse commuting service are likely to be much lower than the estimate above.

Impact of Reverse Commuting Service in Assisting Businesses and Industries with Recruitment and Retention Of Employees

Reverse commuting service by commuter rail would have little impact on the ability of employers to recruit or retain employees. Under the most optimistic

demand estimates, under 1.5% of the workers employed in any city or town would be Boston residents who used commuter rail to get there.

Impacts of Reverse Commuting Services on Traffic Management and Congestion

As discussed above, commuter rail reverse commuting service would attract very small percentages of workers going to any one city or town. Therefore, the overall impacts on traffic congestion would be insignificant. Service with shuttle connections could produce slight reductions in traffic congestion at entrances and exits of suburban employment complexes. Relative to overall traffic levels, however, the impacts would be small. Lightly patronized shuttle services could actually worsen congestion at some employment complexes, because shuttle vehicles would be both entering and exiting in each peak rather than only entering in the morning and departing in the evening. In addition, they could create some backups while stopping to drop off or pick up passengers, or while negotiating access roads designed more appropriately for private autos than for vans or buses.

Present Levels of Reverse Commuting Service

One of the tasks of the study was to estimate the demand for reverse commuting on a commuter rail network with a minimum of three outbound A.M. peak and three inbound P.M. peak trips at every station serving a suburban employment area. As of Spring 2000, of 116 stations (excluding the three in downtown Boston) only 14 (12%) had four or more outbound trains arriving between 6:30 and 9:30 A.M. Another 29 (25%) had three outbound A.M. peak train arrivals. Of the other stations, 38 (33%) had only two outbound A.M. peak trains, 17 (15%) had only one, and 18 (16%) had none. Some of the stations with one train or none were in predominantly residential areas with few employment opportunities. Some others were in areas so far from Boston that they attract few work trips from there. Overall, there was slightly more inbound P.M. peak service than outbound A.M. peak service, but a few stations had even less reverse commuting service in the P.M. than in the A.M.

As noted above, among cities and towns with commuter rail service but not rapid transit or light rail, most of the top 10 providers of jobs for Boston residents already had at least three outbound A.M. peak and three inbound P.M. peak trains by Spring 2000. Since then, service improvements on the Framingham/Worcester Line have put all of the top 10 into this category.

Technical Feasibility and Cost of Increased Reverse Commuting Service

Chapter 4 presents a detailed analysis of the schedule modifications that would be required on each commuter rail line to provide a minimum of three outbound A.M. peak and three inbound P.M. peak trips at most stations. Based on the present average operating cost of \$46.50 per train mile for a six-car train, implementation of all of the service changes described in chapter 4 would increase annual operating cost by about \$13,260,000 a year. At current employment levels, annual revenue to

the commuter rail system would increase by at most \$4,000,000, equal to 30% of the added operating cost, so the annual subsidy level would have to increase by \$9,260,000. Furthermore, part of the \$4,000,000 revenue gain would be offset by losses in revenue on MBTA express and feeder bus routes because of diversions to the new commuter rail service.

The maximum service changes would require acquisition of five train sets that would not otherwise be required to run present service levels. At a cost of \$2,000,000 each for locomotives and \$1,800,000 each for bi-level coaches, the cost of these acquisitions would be about \$58,600,000.

Disregarding diversions from other transit services, the annual operating subsidy per new weekday commuter rail rider would be about \$6,200. This does not include operating costs of feeder connections that would be essential to the success of the train service. The capital cost per new passenger for new train sets alone would be about \$39,300. Costs of fixed facility improvements such as additional passing sidings or second track would add to this. If ridership fell significantly below the optimistic projections above, the average costs would be much higher.

Potential for Feeder Service Connections Between Commuter Rail Lines and Reverse Commuting Destinations along Route 128 and I-495

Chapter 5 examines possible configurations for feeder bus routes from each commuter rail line to nearby employment areas along Routes 128 and I-495. At present, all MBTA commuter rail lines except the Fairmount line extend beyond Route 128, but only the Lowell, Franklin, and Attleboro/Stoughton lines currently have stations directly at the locations where they intersect that highway. The two Old Colony lines do not intersect Route 128, but cross a segment of state Route 3 that was once part of Route 128, so they were included in the analysis.

The Haverhill/Reading, Lowell, Fitchburg, Framingham/Worcester, Franklin, Attleboro/Stoughton, and Middleborough/Lakeville lines all extend beyond I-495. Of these, however, only the Franklin and Middleborough/Lakeville lines have stations at interchanges on that highway. (The Littleton/Rte 495 station on the Fitchburg Line is close to the point where I-495 crosses the rail line, but to drive between the station and highway currently requires traversing about two miles of narrow local roads.)

There are relatively few locations where bus or van connections from commuter rail lines to destinations along Route 128 would be expected to attract enough riders to justify such service. These are from the new Anderson/Woburn Station on the Lowell line to employment centers in Woburn, from Waltham station on the Fitchburg Line to industrial and office parks on both sides of Route 128 in Waltham, and from Route 128 station on the Attleboro/Stoughton Line to employment areas in Westwood and Norwood. Some such service is already provided at all three stations, but ridership on these services has been relatively low. In the case of

Woburn, connecting services have always been provided by individual employers. A service designed to serve multiple work locations would have better demand potential. It would also benefit reverse commuters who were able to walk more conveniently to their work locations from the old Mishawum Station than from the Anderson/Woburn Station.

As discussed in chapter 5, the MBTA is planning to add a side-diversion to bus Route 451 to serve the Cummings Center office park in Beverly, but that complex is closer to downtown Beverly than to Route 128. The bus route originates at the Salem commuter rail station. At present, two outbound A.M. peak trains connect with Route 451 buses, but require waiting times of 19 and 16 minutes. If the bus schedule were to be modified to improve train connections, travel needs of the present bus riders should also be taken into account.

Cities and towns along I-495 all employ much smaller numbers of Boston residents than those served by the Woburn, Waltham, or Route 128 stations, and also draw much smaller percentages of their total labor forces from Boston. The best ridership potential for connecting service in the I-495 corridor appears to be from the new Southborough station being built on the Framingham/Worcester Line to employment areas in Marlborough. Some modifications to existing bus routes operated by the Lowell and Merrimack Valley Regional Transit Authorities in communities on the Newburyport, Haverhill/Reading, and Lowell commuter rail lines could improve connections for reverse commuters. There does not appear to be sufficient demand to justify institution of new dedicated feeder routes in these areas.

Relationship of Reverse Commuting Service to Environmental Justice

Fiscal reality precludes provision of a transit system that would provide transit-dependent residents of Boston with access to all of the same employment opportunities available to residents with autos. In 1990, 83% of Boston residents worked either in Boston itself or in a city or town with rapid transit or light rail connections from Boston. Despite growth in total suburban employment, this proportion would have changed little by 2000. Thus, improvements to the rapid transit and light rail system and connecting bus routes would be expected to improve employment opportunities for much larger numbers of Boston residents than would equally costly improvements in commuter rail reverse commuting service.

Recommendations

The findings in this report indicate that expanding reverse commuting schedules on commuter rail lines would not be a cost-effective method for improving access to employment for Boston residents, for allowing suburban employers to reach a larger labor market, or for relieving suburban traffic congestion problems. These findings can be re-examined when the year 2000 Census Journey-to-Work

tabulations become available in 2002. Because of the high cost of increasing frequency of reverse commuting schedules on commuter rail lines, and the operating constraints affecting such expansion, initial efforts should concentrate on improving connections to employment centers from stations that are already served by at least three outbound A.M. peak and three inbound P.M. peak trains. As discussed in chapter 6, there are already van or bus connections from some commuter rail stations to suburban employment areas, but none of these have attracted large numbers of riders. Other than passenger counts, there is little information as to who is using these services and their reasons for doing so. Surveys of these riders could provide valuable insights about the probable customer base for other such services, and into changes that would be needed to attract significantly greater numbers of riders. It is recommended that if surveys have not already been done by the sponsors of the present services that they be done soon, and that if surveys have already been done, that information from them be shared with the MBTA.

The largest reverse-commuting attractions for Boston residents are now and will likely continue to be those within about 15 miles of downtown Boston. In most cases, better transit access to these destinations could be provided via express buses or via a combination of rapid transit and feeder buses than via commuter rail. Among other reasons, commuter rail is less flexible both in possible frequency and in the choice of specific arrival and departure times that can be offered.

Cities and towns with existing Regional Transit Authority or other community-based bus service may be able to modify routes and schedules to provide improved reverse-commuting connections from commuter rail stations at relatively little cost. Greater familiarity with local conditions should place the operators of such systems in a better position than the MBTA to identify which new services would have the best ridership potential.

1. INTRODUCTION

This study has been prepared for the Massachusetts Bay Transportation Authority (MBTA) by the Central Transportation Planning Staff (CTPS) in response to section 343 of the Fiscal Year 2000 budget passed by the Massachusetts General Court in November 1999. The language of section 343 was as follows:

The Massachusetts Bay Transportation Authority shall prepare a study on the feasibility of providing additional commuter rail and bus transportation services to facilitate reverse commuting services, so-called. Such study shall include, but not be limited to, the following: (1) demand for additional commuter rail services that provide transportation from Boston during both morning and evening rush hour commutes to stations on commuter rail lines; (2) additional bus services and routes necessary to provide north and south connecting services between commuter rail stations located in municipalities along the state highway Route 128 and interstate highway route 495 corridor and the demand for such services; (3) Whether such services assist businesses and industries with the recruitment and retention of employees; and (4) the impact of such services on traffic management and congestion; and (5) analyses of the cost and technical requirements of such reverse commuting services. A report of such study shall be filed with the clerks of the house and senate and the joint committee on transportation and the house and senate committees on ways and means not later than March 1, 2000.

A work program for the Reverse Commuting Study, to be performed by CTPS, was approved by the Sub-Signatory Committee of the Boston Metropolitan Planning Organization (SSC of the MPO) on February 17, 2000. The approved work program included an estimate that the project would require six months from the date that a notice to proceed was received from the MBTA. Issuance of this notice was delayed until July 2000, because the MBTA had no uncommitted planning funds available until that date. Consequently the completion date of the study was extended to December 31, 2000. To allow time for MBTA review of the draft final report and for additional work requested as a result of that review, the project completion date was further extended to June 30, 2001.

2. GENERAL FINDINGS

Context of the Reverse Commuting Issue

Providing transportation for reverse commuters is only one element of the overall problem of linking employment locations with the homes of the workers employed at those locations. The vast majority of Massachusetts residents now live beyond convenient walking distance of their places of employment. Few people are willing to walk more than one mile to work even if they are physically able to do so, because of the time involved. Furthermore, many work locations, particularly in outer suburbs, lack safe walking paths from residential areas.

According to 1990 Census figures, only 5.5% of workers employed in all cities and towns in eastern or central Massachusetts walked all the way from home to work. This proportion is likely to have decreased since then because of the growth of suburban office parks that are far removed workers' homes. In general, the communities employing the highest percentages of walk-to-work employees also ranked low in total employment and therefore offered limited attractions to commuters from beyond their borders. Only three communities with more than 6,000 total jobs also had more than 10% of those jobs accessed by walking. These were Cambridge (107,000 jobs, 13% walk-ins), Somerville (24,000 jobs, 14% walk-ins), and Brookline (19,000 jobs, 12% walk-ins). Somerville had the greatest population per square mile of any community in Eastern Massachusetts (18,498) and Cambridge was a distant second (13,418).

The most common means of traveling to work in eastern or central Massachusetts in 1990 was driving alone, reported by 70% of all workers employed in that area. Only Boston, at 45%, had under half of its workers driving alone, although Cambridge and Brookline were only slightly above half, at 51% and 52%. Excluding these three and Somerville (where 59% drove alone) the average rate of driving to work alone was 80%.

Among workers who did not drive alone, the most common means of travel to work was carpooling with one or two other people. This accounted for about 10% of work trips. Carpools with more than three people, taxis, motorcycles, bicycles, and all forms of public transportation combined accounted for about 15% of all trips to work in eastern or central Massachusetts, but for only 7% to destinations outside of Boston, Cambridge, Brookline, or Somerville. Workers going to jobs in Boston had the highest rate of public transportation use of those going to any destination, at 34%. Cambridge was second, at 21%.

Suitability of Commuter Rail for Reverse Commuting

The low rate of public transportation use for work trips to destinations outside Boston in the figures above is in part a reflection of the limited or non-existent mass transit links to those destinations. The absence of such links is itself largely a result of the difficulty of providing mass transit services that would meet the travel needs and wants of workers going to those destinations. The concept of providing mass transit service

often differs greatly from what could actually be done at acceptable cost. Advocates of new public transportation services often overlook the inherent limitations of the modes they are lobbying for.

To function efficiently, a public transportation route must be able to attract groups of people who need to travel at the same times between origins and destinations served either directly or by convenient connecting modes. In general, the higher the capacity of the vehicles used on a route is, the greater the average number of users per trip must be to justify operation. To attract riders, a new service must either be perceived as superior to previous alternatives used to make the same trip, or it must induce people to make trips that they would not otherwise have attempted.

No public transportation alternative can offer the direct door-to-door service provided by private auto travel. Of all mass transit alternatives, commuter rail is among the least flexible in what it is able to offer. Including branches that diverge outside Boston, MBTA commuter rail service is currently operated on a total of five routes out of North Station and eight out of South Station. Restoration of service on a few additional routes that are currently used only for freight service or are inactive is planned or under study. Even with maximum expansion, however, not every city and town will have commuter rail service, and not every section of every city or town that does have service will have a station nearby.

The commuter rail network resembles spokes radiating from downtown Boston. Train travel to a station outside Boston on any route is possible only from other stations on the same route. Transfers between most routes can be made only by traveling into Boston. In attempting to attract riders, trade-offs are necessary between maximizing the number of stops to serve more points directly and minimizing stops to allow faster average speeds. Counting stations on the border of two towns as being in both, the commuter rail system currently provides direct service to 71 cities and towns outside Boston, and new stations about to be constructed on the Framingham / Worcester line will bring the total to 74. Of these municipalities, 49 (66%) have only one station each. Another 17 (23%) have two stations. Six cities and towns (8%) have three commuter rail stations each, but in most of these some of the stations have only limited service. The only municipalities with more than three stations are Needham, with four, and Beverly, with five. One station in Beverly has very limited service.

Because few riders are willing and able to walk more than about one mile to reach a boarding station, the commuter rail system is heavily dependent on connecting transportation for access. The 1993 MBTA commuter rail survey found that for the system as a whole, 28% of inbound riders (i.e. riders on trains going toward Boston) walked to their boarding stations, 56% drove and parked, 14% were dropped off, and only 1% used feeder buses. The 1998 Old Colony survey found a combined walk-in rate of only 10% to the two branches. The high use of forms of auto access is made possible by high suburban auto ownership rates. Reverse commuters would not have autos waiting for them at their outer alighting stations. Those going to jobs beyond walking distance of the stations would need to be provided with connecting transportation.

Operating Constraints on Commuter Rail Reverse Commuting Service

At present, most of the reverse commuting service provided by the MBTA commuter rail system is provided as a by-product of peak-direction service. Specifically, most trains going outbound (away from Boston) in the A.M. peak are either going back to do another trip after completing an inbound run or are making an initial trip to an outer endpoint from an overnight storage facility close to Boston. Similarly, most inbound P.M. peak trains are either returning to Boston after a midday outbound trip in order to do an outbound peak trip, or are returning after a peak trip to do another trip or to go to overnight storage.

Because of the lengths of the commuter rail lines, most trains running out from Boston before their first inbound trips of the day must leave Boston too early in the morning to be of practical use to many reverse commuters. Passengers using these trains would arrive at work much earlier than the beginnings of their work days, and in many cases trains would leave Boston earlier than the downtown stations could be accessed by connecting transit. At the other extreme, many of the scheduled inbound arrivals occur too late in the A.M. peak to allow the equipment to turn to outbound trains at times useful to many reverse commuters. At many stations inbound P.M. peak service is more frequent than outbound A.M. peak service, but commuters choose their modes on the basis of both convenient arrivals and convenient departures at their work locations.

The present commuter rail schedules require the use of all locomotives and cars in the fleet, with only a minimum held out as spares for routine or emergency maintenance. Any new reverse commuting service that could not be provided by sharing equipment used in the peak-direction schedules would require either discontinuance of a peak-direction trip or acquisition of additional rolling stock. As detailed elsewhere in this report, the potential ridership on new reverse commuting trains would be much lower than that on peak-direction peak-period trains. Discontinuing a peak-direction trip would force its riders either to use trains at less convenient times or to change modes. It would also result in overcrowding of remaining trips, since most peak trains now have little or no excess capacity. Therefore, discontinuing a peak-direction trip to provide equipment for a reverse commuting trip would inconvenience far more people than it would benefit.

Because other commuter rail systems have similar rolling stock shortages, no used equipment is currently available either for sale or lease. New locomotives currently cost about \$2,000,000 each, and coaches about \$1,800,000 each. For scheduling efficiency, new trainsets must be interchangeable with the present ones. A set for the North Side lines would need at least five coaches, at a cost of about \$11,000,000 including the locomotive. A set for the South Side lines would need at least six coaches at a cost of \$12,800,000. Because of a limited number of suppliers and a backlog of orders, the delivery time from order to delivery of new rail cars is usually about two years.

Aside from the problem of providing equipment, potential reverse commuting schedules are constrained by the configurations of the rail lines themselves. Most of the

lines in the MBTA commuter rail system have one or more segments of single track. Schedules must be arranged so that trains in opposite directions meet either on double-track sections or at passing sidings within single-track sections. If it is impossible to arrange a schedule that does not require one train to stop at some point to wait for an opposing train, priority is usually given to the more heavily patronized of the two. This would invariably be the peak-direction train rather than the reverse commuting train. Even with careful scheduling, a delay to one train can cause propagation of delays to several others. With a limited number of equipment sets, the time at which a train should depart from its terminal in order to minimize delays on single track sections often does not match the time that rolling stock is available to run the trip.

Appendix A of this report provides more specific details on single-track constraints on each of the commuter rail lines. Also discussed in that appendix are constraints imposed by rolling stock availability, by track capacities at the Boston terminals and maintenance facilities, and by shared use of tracks with freight trains.

Chapter 4 contains a detailed analysis of the feasibility of providing a minimum of three outbound A.M. peak and three inbound P.M. peak trains at each station that currently has service less frequent than that.

Potential Demand for Commuter Rail Reverse Commuting Service

Differences in Attraction Rates in Boston Proper and Outlying Neighborhoods

The vast majority of passengers making inbound trips on the commuter rail system are going from home to work in Boston or Cambridge. In the 1993 survey, such trips accounted for 87% of the riders on South Side lines and for 79% of those on North Side lines. In the Old Colony survey, the figure was 78%. Among those with work destinations in the city of Boston, 92% of those on the North Side lines, 90% of those on older South Side lines, and 87% on Old Colony Lines were destined for Boston Proper. (This is defined approximately as the area enclosed by Massachusetts Avenue, the Charles River, Boston Harbor, Fort Point Channel, and the Southeast Expressway.) In contrast, only 55% to 60% of work trips to Boston by all modes combined from the same communities served by commuter rail ended in Boston Proper. Mathematically, this implies that a passenger going to work in Boston Proper is seven times as likely to use commuter rail as a passenger from the same origin town going to work in another part of Boston. This occurs although connections from commuter rail to points throughout the city are possible by rapid transit or by combinations of rapid transit and bus.

The vast majority of members of the Boston resident labor force live outside Boston Proper. The 1990 Census figures show that this was the case for 86% of Boston residents who were employed anywhere other than Boston. The same connecting rapid transit and bus services used by suburban commuters to reach outlying areas of Boston from downtown commuter rail stations provide reverse commuters from homes in these neighborhoods with access to commuter rail boarding stations. Thus, it would be expected that for those with other options, the need to use these connections would

deter use of commuter rail for reverse commuting to about the same extent that it deters commuting toward Boston.

Impact of Connections at Commuter Rail Outer Trip Ends

At the outer trip ends, most suburban residents living beyond walking distance of stations drive and park or are dropped off. Reverse commuters going to jobs beyond walking distance of stations must rely on feeder buses and vans or taxis. At present, van or bus service is provided at only a small number of stations, and there it provides connections to only limited numbers of employers. Unless subsidized by employers, taxi service is too expensive for most commuters to use on a daily basis. Most individual employers have too few potential reverse commuting workers to support dedicated bus or van service, but the more employers served by a feeder route the slower and less direct it becomes and the less attractive it is to commuters.

Among present users of the commuter rail system, perceived convenience is a very important factor in selection of this mode over other alternatives. In the 1998 survey of Old Colony commuter rail passengers, 70% of the respondents checked convenience as one of their main reasons for using the service. In the 1993 survey of older commuter rail lines, the percentages citing convenience were even higher. Ease of access and egress would be among the attributes considered in rating convenience.

Almost all residents of towns with commuter rail stations have some means of access to those stations, but the commuter rail share of work trips from those towns to downtown Boston seldom exceeds 50% and is usually much lower. Thus, it is reasonable to assume that commuter rail could capture much less than 50% of reverse commuting trips from Boston Proper to a town where connecting van or bus service was only provided to limited numbers of destinations. With a need to transfer at the Boston end deterring reverse commuters at the same rate observed in commuting trips toward Boston, even a service that attracted 50% of reverse commuters from Boston Proper would attract only about 7% of those from other parts of Boston.

Impact of Traffic Congestion and Parking Fees

The most important reason cited by Old Colony commuter rail riders for using that service was “Avoid driving/traffic,” checked by 73% of the survey respondents. (This was not one of the check-off choices offered on the 1993 survey. It was included on the Old Colony survey because of the large number of respondents who used it as a write-in reason in 1993.) Reverse commuters from Boston to suburban work locations travel in the opposite direction from the predominant flows of highway traffic. Although they encounter congestion at some locations, such as at interchanges and on local roads between main highways and work locations, their overall journeys typically include much smaller percentages of travel on congested segments than the trips of suburban residents working in Boston. Therefore, avoidance of traffic and congestion would be expected to be a much smaller incentive for reverse commuters to use mass transit than it is for Boston workers.

Downtown Boston parking cost and availability were cited by 25% of Old Colony riders and about the same proportion of 1993 survey riders as a reason for using commuter rail. This average would include responses from riders with parking options ranging from free or partly subsidized on-site parking provided by employers to high-cost parking at some distance from the work location. The survey did not provide a means of distinguishing among these riders, but presumably among the latter the proportion concerned with parking availability and cost would have been much higher than 25%.

Suburban work locations such as office and industrial parks that would be expected to attract the majority of reverse commuters from Boston usually offer enough free on-site parking for everyone working there. The main issue of concern relative to parking for commuters driving to work would be walking distance in the parking lot from parking space to work site. Hence, parking cost and availability at the work location would be of little or no concern to most reverse commuters from Boston in deciding whether to switch to mass transit. Parking concerns, could, however, be a major disincentive to use of commuter rail for reverse commuters from suburban origins. Most such riders would have to compete with Boston-bound riders for scarce parking space at or near their boarding stations, and in most cases they would have to pay to park.

Impact of Rapid Transit Competition

In communities served both by the rapid transit system and the commuter rail system, the commuter rail share of travel to and from Boston is insignificant compared with the rapid transit share. Contributing factors include greater numbers of stations, greater frequency, lower fares, more extensive feeder services and more direct downtown distribution offered by rapid transit lines. Because of this, the analysis in this study of demand for reverse commuting service on commuter rail concentrated on destinations not served by rapid transit.

Calculations of Commuter Rail Potential Share of Reverse Commuting Trips

Including three towns in which new stations are about to be built on the Framingham / Worcester Line, a total of 68 of the cities and towns served directly by commuter rail are not also served directly by rapid transit. Boston residents account for relatively small shares of total workers employed in these localities. The number of new reverse commuters attracted even by improved commuter rail service with van connections would be too small to change the Boston shares of these totals significantly. In the 1990 Census, among the 68 cities and towns meeting the criteria above, only three had at least 10% of their jobs filled by Boston residents. These were Dedham (18%), Chelsea (11%) and Westwood (10%). Dedham borders directly on two outlying Boston neighborhoods: Hyde Park and West Roxbury. Westwood is separated from Boston only by Dedham. Chelsea is linked directly by bridges with Charlestown and East Boston. In 54 of the 68 cities and towns, under 5% of jobs were held by Boston residents. Total employment in most of these communities increased between 1990 and 2000, but in the same span, the number of Boston residents employed anywhere declined by 1.2%. Therefore, the proportion of jobs in these communities held by

Table 2-1
Estimated Maximum Commuter Rail Reverse Commuting Trips
to Cities and Towns Served Directly By Commuter Rail but not by Rapid Transit
with 1999 Employment Levels and Expanded Service Frequency

Destination City or Town	Projected 1999 Rail Riders			% of Total City or Town Employment
	Boston Proper	Boston Other	Total	
Waltham	298	316	614	1.01%
Woburn	144	82	226	0.71%
Dedham	8	190	198	1.33%
Framingham	118	69	188	0.47%
Norwood	45	140	185	0.79%
Needham	63	113	176	1.01%
Chelsea	64	104	168	1.17%
Natick	91	60	152	0.65%
Wellesley	50	100	150	0.78%
Lynn	71	69	140	0.49%
Canton	45	71	115	0.67%
Westwood	37	59	96	1.10%
Stoughton	52	35	87	0.62%
Brockton	31	38	69	0.19%
Wilmington	40	27	68	0.35%
Randolph	22	45	67	0.71%
Westborough	51	12	63	0.33%
Concord	42	19	62	0.44%
Andover	37	21	58	0.20%
Wakefield	33	25	58	0.41%
Belmont	25	23	48	0.78%
Beverly	35	11	46	0.24%
Winchester	36	9	45	0.55%
Worcester	27	16	44	0.04%
Sharon	24	20	44	0.97%
Salem	24	19	43	0.25%
Weston	31	12	43	1.47%
Lowell	28	14	41	0.14%
Weymouth	16	26	41	0.23%
Reading	15	21	36	0.42%
Billerica	17	18	36	0.15%
Walpole	10	21	31	0.33%
Bridgewater	21	9	29	0.30%
Lawrence	22	7	28	0.14%

Destination City or Town	Projected 1999 Rail Riders			% of Total City or Town Employment
	Boston Proper	Boston Other	Total	
Acton	18	10	28	0.26%
Melrose	19	8	28	0.40%
Littleton	15	6	21	0.32%
Wenham	16	0	16	0.62%
Mansfield	0	14	14	0.13%
Gloucester	0	13	13	0.10%
Abington	10	2	12	0.27%
Norfolk	6	6	12	0.34%
Holbrook	8	4	12	0.37%
Franklin	0	11	11	0.09%
Halifax	7	3	10	1.03%
Newburyport	7	3	10	0.11%
Ayer	7	1	8	0.11%
Fitchburg	6	2	8	0.05%
Haverhill	6	1	7	0.05%
Hanson	5	2	7	0.27%
Lakeville	6	1	7	0.17%
Southborough	0	7	7	0.10%
Plymouth	0	6	6	0.03%
Lincoln	0	6	6	0.38%
Leominster	5	0	5	0.03%
Middleborough	5	0	5	0.07%
Ipswich	0	5	5	0.11%
Attleboro	0	4	4	0.03%
Kingston	0	4	4	0.09%
Ashland	0	3	3	0.07%
Manchester	0	3	3	0.14%
Whitman	0	2	2	0.07%
Swampscott	0	2	2	0.04%
Grafton	0	1	1	0.02%
Rowley	0	1	1	0.04%
Hamilton	0	0	0	0.00%
Shirley	0	0	0	0.00%
Rockport	0	0	0	0.00%
Total	1,819	1,952	3,771	0.40%

Table 2-2

Destination City or Town	Projected 1999 Rail Riders			Spring 2000 Boston Ons	
	Boston Proper	Boston Other	Total		
Waltham	298	316	614		
Concord	42	19	62		
Belmont	25	23	48		
Acton	18	10	28		
Littleton	15	6	21		
Ayer	7	1	8		
Fitchburg	6	2	8		
Lincoln	0	6	6		
Leominster	5	0	5		
Subtotal Fitchburg Line	417	382	799	211	
Framingham	118	69	188		
Natick	91	60	152		
Wellesley	50	100	150		
Westborough	51	12	63		
Worcester	27	16	44		
Weston	31	12	43		
Southborough	0	7	7		
Ashland	0	3	3		
Grafton	0	1	1		
Subtotal Framingham / Worcester Line	368	281	650	229	
Dedham	8	190	198		
Canton	45	71	115		
Westwood	37	59	96		
Stoughton	52	35	87		
Sharon	24	20	44		
Mansfield	0	14	14		
Attleboro	0	4	4		
Subtotal Attleboro / Stoughton Line	166	393	558		159
Chelsea	64	104	168		
Lynn	71	69	140		
Beverly	35	11	46		
Salem	24	19	43		
Wenham	16	0	16		
Gloucester	0	13	13		
Newburyport	7	3	10		
Ipswich	0	5	5		
Manchester	0	3	3		
Swampscott	0	2	2		
Rowley	0	1	1		
Subtotal Newburyport / Rockport Line	218	228	446	238	

Destination City or Town	Projected 1999 Rail Riders			Spring 2000 Boston Ons	
	Boston Proper	Boston Other	Total		
Woburn	144	82	226		
Wilmington	40	27	68		
Winchester	36	9	45		
Lowell	28	14	41		
Billerica	17	18	36		
Subtotal Lowell Line	264	151	416		236
Norwood	45	140	185		
Walpole	10	21	31		
Norfolk	6	6	12		
Franklin	0	11	11		
Subtotal Franklin Line	61	178	239		113
Andover	37	21	58		
Wakefield	33	25	58		
Reading	15	21	36		
Lawrence	22	7	28		
Melrose	19	8	28		
Haverhill	6	1	7		
Subtotal Haverhill / Reading Line	132	83	215		140
Brockton	31	38	69		
Randolph	22	45	67		
Bridgewater	21	9	29		
Holbrook	8	4	12		
Lakeville	6	1	7		
Middleborough	5	0	5		
Subtotal Middleborough / Lakeville Line	92	97	189	48	
Needham	63	113	176		
Subtotal Needham Line	63	113	176		95
Weymouth	16	26	41		
Abington	10	2	12		
Halifax	7	3	10		
Hanson	5	2	7		
Plymouth	0	6	6		
Kingston	0	4	4		
Whitman	0	2	2		
Subtotal Plymouth / Kingston Line	37	46	83		40
Total all Lines	1,819	1,952	3,770	1,509	

Boston residents is more likely to have decreased than increased. In times of a strong economy such as the late 1990s, Boston residents have limited incentives to work in outer suburbs because equally attractive opportunities are available closer to home. In a weaker economy, suburban employers would have little reason to subsidize transportation of workers from Boston because jobs could be filled by local residents.

Maximum estimates of reverse commuting by commuter rail would be obtained by assuming that the percentages of suburban jobs held by Boston residents have held steady since 1990 and applying to these the best-case rail shares of 50% from downtown Boston and 7% from the rest of Boston. The results of such calculations are shown in Tables 2-1 and 2-2. At the time this report was prepared, the most recent available total employment figures by city and town were for 1999 and these were used in calculating the results in the tables. (For the Eastern Mass. Regional Planning Project area as whole, actual 1999 employment was very close to forecasts for the year 2000 made by the Metropolitan Area Planning Council.) In Table 2-1 results for all of the 68 cities and towns are sorted in descending order of demand potential. In Table 2-2 results are shown on a line-by-line basis and comparisons with observed outbound A.M. peak boardings on these lines at the downtown Boston stations are included. Estimates of reverse commuting trips from Boston to individual destination stations appear in Table 3-1 in chapter 3.

Under the assumptions above, the maximum number of reverse commuters likely to use commuter rail to any one city or town at present employment levels would be 614, to Waltham. This estimate does not take into account the fact that most of the major employers in Waltham are located along Route 128 and do not have convenient access by commuter rail. They are, however, served directly by shuttle vans from the Red Line Alewife terminal and by MBTA buses from Cambridge and from downtown Boston. Even with 614 riders, commuter rail would be carrying only 1.0% of all workers employed in Waltham, and many of these would not be new transit users. Both commuter rail stations in Waltham (Waltham and Brandeis/Roberts) already have the minimum objective three outbound A.M. peak and three inbound P.M. peak trains. Spring 2000 counts showed a total of 211 riders boarding the three outbound A.M. peak Fitchburg Line trains in Boston for all destinations and trip purposes. As shown in Table 3-1, these included at most about 75 riders making work trips from Boston to Waltham.

The next-largest commuter rail reverse commuting potential would be to Woburn, at 226. As of December 2000, Mishawum Station in Woburn served about 80 A.M. peak reverse commuters a day. Very limited connecting service was provided there. MBTA express bus Routes 354 and 355 currently provide reverse commuting service directly to other sections of Woburn from downtown Boston. No other city or town would be expected to have more than 200 reverse commuters by commuter rail, and all but 11 would be expected to have fewer than 100 each. Half of all the riders would be destined for the top eight cities and towns. At the opposite extreme, over 20% of the riders would be scattered among 48 cities and towns, each of which would attract fewer than 50 riders.

In general, the further a community in a given corridor is from Boston, the smaller the number of reverse commuters it attracts from there. Of the 68 cities and towns with commuter rail service but not rapid transit, 11 are located along Route I-495. The number of commuter rail reverse commuters attracted to any of these would not be expected to exceed 65, and in seven of them it would not exceed 25.

Tables 2-1 and 2-2 do not include forecasts for Providence Station on the Attleboro / Stoughton Line. Available employment figures are not sufficiently detailed to allow forecasts for reverse commuting to destinations outside Massachusetts to be done by a method consistent with that used to produce the other results in the tables. As discussed in chapter 4, the one outbound A.M. peak train now run to Providence currently serves only about 13 riders a day traveling from homes in Boston to work locations in or near Providence. Additional Providence trains would each be expected to attract similar ridership.

Again, it should be emphasized that even to attain the ridership levels estimated in the tables, it would be necessary to provide extensive connecting services from stations to employment locations. The best-case estimates also ignore the smaller roles of traffic congestion, parking availability, and parking costs in the mode choices of reverse commuters than in those of commuters to Boston.

Several of the communities in which commuter rail lines intersect I-495 are already served by regional transit authorities or town-sponsored bus systems, which also serve adjoining towns not on the rail lines. Newburyport, Haverhill, Andover, and Lawrence are all served by the Merrimack Valley Regional Transit Authority. Lowell is served by the Lowell Regional Transit Authority. Southborough is served by the Framingham LIFT system. In some cases, minor adjustment to schedules or alignments of existing routes would improve their ability to act as collectors and distributors for commuter rail reverse commuting trips. Whether feeder services are provided with new or modified routes, the present local transit agencies or operators should be in a better position than the MBTA to determine where and when they should run.

The ridership estimates above and in Table 2-1 are based on the best information available at this writing on current population and employment in the MBTA commuter rail service area. Projections of ridership in future years always require some assumptions about the changes that will occur in population and employment levels. Appendix B of this report examines the impacts that anticipated changes by the years 2010 and 2020 would have on demand for reverse commuting service. Also examined are travel markets in addition to work trips from Boston to suburban locations that would be served by added reverse commuting trains.

The conclusion of appendix B is that the viability of reverse commuting service and the benefits to workers and employers would not be significantly greater by the year 2020 than they would be if service were in operation now. The time frame that would be needed for implementation of reverse commuting service would be sufficiently short

that deferring it now would not preclude future implementation if actual changes in travel patterns indicated that such service was justified.

Impact of Reverse Commuting Service in Assisting Businesses and Industries with Recruitment and Retention Of Employees

Demand for reverse commuting service from Boston is discussed above. Based on very optimistic estimates, commuter rail reverse commuters would account for less than 1% of all workers employed in 61 of 68 cities and towns served by commuter rail but not by rapid transit. In the rest, the shares would be less than 1.5%. In absolute terms, no more than 200 riders would be carried to any city or town except Waltham or Woburn, where the numbers would about 615 or 225 at most. Some of these riders would use other means of transportation to the same jobs if commuter rail service were not available.

In overall terms of helping suburban employers fill jobs, the impact of commuter rail reverse commuting service would be negligible, but some employers would benefit more than others. Employment in most suburban communities is provided by hundreds or thousands of small businesses and a few large ones. Average work forces of around 20 per employer are typical. For firms at the lower end in employment size, recruitment of even one or two new workers could be significant. At the same time, the kind of employment offered by many small businesses is unlikely to attract workers from long distances no matter what transportation alternatives are available.

Employers themselves are in a better position to judge whether the jobs they are trying to fill and the compensation they are offering match the skills of workers available from different areas and their salary and benefit expectations. The most successful reverse commuting services are likely to be ones designed to link specific residential areas with specific employment sites, accompanied with active worker recruitment efforts in the target areas. In most cases, bus or van service through from origin to destination would prove better suited to this task than commuter rail combined with feeder services at one or both trip ends.

Impacts of Reverse Commuting Services on Traffic Management and Congestion

As discussed above, commuter rail reverse commuting service would attract very small percentages of workers going to any one city or town. Therefore, the overall impacts on traffic congestion would be insignificant. The most severe traffic backups in commuting hours are likely to occur either at entry and exit ramps of limited-access highways or at the entrances of parking lots of major employers. Most suburban employment locations are beyond walking distance of the nearest commuter rail stations, so workers using commuter rail would still have to arrive and depart in vehicles using the same roads taken by auto drivers. Depending on station locations relative to destinations, some shuttle vehicles would also use limited-access highway ramps.

Ridership figures for existing shuttle services from rapid transit or commuter rail stations show that those serving multiple employers typically carry maximums of 15 to 20 riders per trip, and that those serving only one employer usually carry no more than about five riders per trip. Either kind of service may carry even fewer riders, but trips with the highest totals are also likely to run at times of heaviest traffic. If shuttle passengers traveled instead in individual autos, their arrivals and departures would be expected to be spread out over some span of time rather than occurring simultaneously.

The design of many suburban office and industrial complexes makes it necessary for shuttle vehicles to pull off the main road into parking lots to pick up or drop passengers safely. Unless the shuttle vehicle is at the end of its run, each stop generates one entry and one exit turning move between the main road and the parking lot. In contrast, each single-occupant auto commuter makes one entering turning move at the start of the workday and one exiting move at the end of the workday. Larger shuttle vehicles may be somewhat less maneuverable than autos, and therefore block traffic slightly longer during turning moves.

In conclusion, commuter rail reverse commuting service with shuttle connections could produce slight reductions in traffic congestion at entrances and exits of suburban employment complexes. Relative to overall traffic levels, the impacts would be small.

Relationship of Reverse Commuting Service to Environmental Justice

An ideal transit system would allow workers without cars to have access to the same employment opportunities available to those with cars. Fiscal reality precludes provision of such a transit system, however, as the potential volume between many origin-destination pairs would be too low to justify service. Since it is impossible to offer public transportation from every home to every potential work destination, the next-best strategy is to try to maximize choices in work locations available to the transit-dependent.

The city of Boston itself accounts for the largest share by far of work trip destinations of Boston residents, at 68.5% as of 1990. The number was so large that even with expected growth in suburban employment the proportion of Boston residents working in Boston is unlikely to have dropped appreciably. Neighboring communities connected with Boston by rapid transit or light rail accounted for 14.9% of Boston residents' work locations in 1990. (These were Cambridge, Newton, Brookline, Quincy, Braintree, Somerville, Revere, Medford, Malden, and Milton.) Most of these have extensive networks of MBTA feeder bus service connecting the rail lines with points in the same communities and in neighboring ones.

Boston and the 10 cities and towns listed above offer employment for people with a wide range of skills and experience. With a limited operating budget, devoting resources to improvements in transit service within Boston and nearby cities and towns would produce much greater benefits for transit-dependent Boston residents than would increasing the frequency of commuter rail reverse-commuting schedules.

3. PRESENT REVERSE COMMUTING SERVICE FREQUENCY AND RIDERSHIP

Introduction

This chapter describes levels of service suitable for reverse commuting on the MBTA commuter rail system as of Spring 2000, along with available information on ridership levels on that service. Frequency at most stations was still the same in Spring 2001, but exceptions are noted. Spring 2000 frequencies are used in the tabulations because CTPS counts of ridership in and out of Boston on all peak-period commuter rail trains were done most recently then. In general terms, reverse commuting is defined as repetitive trips from home to work or school in the direction opposite to that of predominant peak travel. For the commuter rail system, such trips would be made on trains traveling outbound (away from Boston) in A.M. peak hours and inbound in P.M. peak hours.

The legislation mandating this study was concerned primarily with work trips from homes in Boston, but on several of the commuter rail lines reverse commuting by students accounts for a significant portion of all outbound A.M. peak travel. In such cases, passenger counts alone would give a false impression of the potential for reverse commuting work trips. Therefore, on lines where information about school travel is available it is included below.

For many years, most of the reverse commuting service operated on MBTA commuter rail lines has been provided as a by-product of peak-direction service. Trains running outbound in A.M. peak hours or inbound in P.M. peak hours have done so primarily to reposition equipment for peak-direction trips rather than to serve the reverse commuting market. Consequently, choices of arrival times at the majority of possible reverse commuting destinations have been very limited. In addition to having a choice of arrival times, in order for a station to serve reverse commuters it must either be within walking distance of one or more large trip attractors, or have some form of connecting service to such attractors available. Many of the stations on the commuter rail system are in predominantly residential areas, with little potential as work or school trip destinations regardless of the level of service provided.

Levels of Reverse Commuting Service in Spring 2000

At present, the MBTA designates inbound A.M. peak trains on most commuter rail lines as those arriving at the Boston terminals between 6:30 and 9:00 or 9:30 A.M. There is no official definition of outbound A.M. peak service, but the greatest numbers of reverse commuters would also need to reach their destinations between 6:30 and 9:30 A.M. Outbound trains leaving Boston at the beginning or end of the A.M. peak would provide such arrival times at some stations but not others because of differences in running times. In Spring 2000, of 116 stations (excluding the three in downtown Boston) only 14 (12%) had four or more outbound trains arriving between 6:30 and 9:30 A.M. Another 29 (25%) had three outbound A.M. peak train arrivals. Of the other stations, 38, (33%) had only two outbound A.M. peak trains, 17 (15%) had only one, and 18 (16%) had none.

Greater frequency does not necessarily equate to greater attractiveness if the specific arrival and departure times are not convenient for commuters in the corridors served.

Reverse commuters require convenient departure times for their homeward trips as well as convenient arrival times at their outbound destinations. On most MBTA commuter rail lines, outbound trains departing Boston between 3:30 and 6:30 p.m. are classified as P.M. peak service. The majority of trips home from reverse commuting destinations would also be expected to require departure times in this span. Overall, there is slightly more inbound P.M. peak service than outbound A.M. peak service, but a few stations have even less reverse commuting service in the P.M. than in the A.M. Because of the limited service available, counts of present reverse commuters at many stations would provide an incomplete measure of market potential.

Table 3-1 shows the number of A.M. peak and P.M. peak reverse commuting trains stopping at each station in the Spring 2000 schedules. Stations are arranged in descending order of the number of A.M. peak trains. Stations with equal numbers of A.M. peak trains are arranged by route, in counter-clockwise order of direction from Boston starting with the Newburyport/Rockport Line and ending with the Plymouth/Kingston Line. Within routes, stations are arranged in order of increasing distance from Boston.

The remainder of this chapter presents the available information about outbound A.M. peak and inbound P.M. peak ridership between Boston and each MBTA commuter rail station in greater detail. General characteristics of the areas served by stations in terms of potential for attracting work trips are also included. Other transportation alternatives available for reverse commuting to the stations areas are listed. In most cases, commuter rail offers faster line-haul travel times than express bus service or combinations of local buses and rapid transit. Offsetting this advantage, bus service often offers more frequent departure times and lower fares. Bus routes also offer a greater choice of boarding and alighting points, bringing passengers closer to their trips origins and destinations than commuter rail is able to.

Stations with Six Outbound A.M. Peak Trains

In Spring 2000, only three stations in the system had more than five reverse commuting trains in either peak period. These were Beverly Depot and Salem on the Newburyport/Rockport Line and Readville on the Fairmount and Franklin lines.

Beverly Depot and Salem

The same six outbound trains stopped at both Beverly Depot and Salem in the A.M. peak. In the P.M. peak six inbound trains stopped at Beverly Depot, and all but one of these also stopped at Salem. Counts at North Station in Spring 2000 found a total of 231 riders boarding the six outbound A.M. peak trains there, or an average of 38.5 per train. Alighting counts by station were not done for most of these trains, except at Chelsea, where there were about 40 outbound A.M. peak alightings. This shows that about 190

Table 3-1

MBTA Commuter Rail Year 2000 Reverse Commuting Train Frequency and Approximate Weekday Boston Riders by Station

A.M. Peak Outbound Arrivals	P.M. Peak Inbound Departures	Approx. A.M. Peak Riders	Station	A.M. Peak Outbound Arrivals	P.M. Peak Inbound Departures	Approx. A.M. Peak Riders	Station	A.M. Peak Outbound Arrivals	P.M. Peak Inbound Departures	Approx. A.M. Peak Riders	Station	A.M. Peak Outbound Arrivals	P.M. Peak Inbound Departures	Approx. A.M. Peak Riders	Station
6:30-9:30	3:30-6:30	from Boston		6:30-9:30	3:30-6:30	from Boston		6:30-9:30	3:30-6:30	from Boston		6:30-9:30	3:30-6:30	from Boston	
Salem	6	5	45	Needham Center	3	3	10	Natick	2	2	29	Endicott	1	1	2
Beverly Depot	6	6	60	Needham Heights	3	3	10	West Natick	2	2	15	Windsor Gardens	1	1	4
Readville	6	5	13	Norwood Central	3	3	35	Framingham	2	3	58	Norfolk	1	2	5
Chelsea	5	4	56	Ruggles	3	0	7	Forest Hills	2	3	2	Franklin	1	2	9
Route 128	5	4	109	Canton Center	3	1	5	Roslindale	2	2	1	Forge Park	1	2	2
Canton Junction	5	4	30	Stoughton	3	1	20	Bellevue	2	2	1	Providence	1	2	13
Lynn	4	3	40	Mansfield	3	3	35	Highland	2	2	1	Halifax	1	3	2
Swampscott	4	3	10	Attleboro	3	3	38	Dedham Corp.	2	3	19	Kingston	1	2	10
Malden	4	3	0	Uphams Corner	3	4	2	Walpole	2	2	20	Prides Crossing	0	0	0
Melrose / Cedar	4	3	2	Morton	3	4	1	Sharon	2	3	6	Hastings	0	0	0
West Medford	4	4	10	Fairmount	3	4	5	South Attleboro	2	2	16	Silver Hill	0	0	0
Winchester	4	4	25	Quincy Center	3	2	2	Holbrook	2	3	2	Littleton / Rte 495	0	0	0
Mishawum	4	5	80	Braintree	3	1	3	Montello	2	3	1	Ayer	0	0	0
Wilmington	4	3	21	Montserrat	2	2	6	Brockton	2	3	15	Shirley	0	0	0
River Works	3	5	12	Beverly Farms	2	2	6	Campello	2	3	5	North Leominster	0	0	0
Wyoming	3	2	0	Manchester	2	2	6	Bridgewater	2	3	20	Fitchburg	0	0	0
Melrose Highl'nds	3	4	0	West Gloucester	2	2	2	Middleboro	2	2	7	Newtonville	0	1	0
Wakefield	3	3	22	Gloucester	2	2	10	South Weymouth	2	1	6	West Newton	0	1	0
Reading	3	3	32	North Beverly	2	3	5	Abington	2	1	2	Auburndale	0	1	0
Wedgemere	3	4	8	Hamilton-Wenh'm	2	3	5	Whitman	2	1	7	Grafton	0	0	0
North Billerica	3	4	5	Ipswich	2	3	6	Hanson	2	1	2	Worcester	0	0	0
Lowell	3	4	20	Rowley	2	2	2	Rockport	1	2	3	Islington	0	2	0
Porter Square	3	3	25	Newburyport	2	2	7	Greenwood	1	2	0	Norwood Depot	0	0	0
Waltham	3	3	45	Belmont	2	3	9	No. Wilmington	1	0	0	Plimptonville	0	0	0
Brandeis / Roberts	3	3	30	Waverley	2	2	7	Ballardvale	1	2	4	Hyde Park	0	4	0
Concord	3	3	15	Kendal Green	2	3	5	Andover	1	2	4	Plymouth	0	1	0
Wellesley Hills	3	2	20	Lincoln	2	3	5	Lawrence	1	2	28				
West Roxbury	3	3	5	West Concord	2	3	10	Bradford	1	2	14				
Hersey	3	3	5	South Acton	2	3	20	Haverhill	1	2	10				
Needham Junction	3	3	10	Wellesley Square	2	2	51	Wellesley Farms	1	2	5				

riders traveled from Boston to all stations north of Chelsea. As discussed below, about 40 riders from these trains alighted at Lynn and Swampscott, leaving about 150 for all other stations. Because they had the most frequent service, and also were within walking distance of many employment opportunities, Salem and Beverly would be expected to have accounted for a substantial share of that ridership.

Reasonable estimates would be 45 outbound trips at Salem and 60 at Beverly, but these would not all be work trips. For comparison, the 1993 survey found only 21 P.M. peak work-to-home trips from Salem and only 13 from Beverly Depot. There were also 12 school-to-home trips boardings at Salem in the P.M. peak, mostly from Salem State College. At Beverly there were four P.M. peak school-to-home trips from North Shore Community College. Similar totals in 2000 would reduce the upper limits on reverse commuting work trips at these stations to about 35 and 55.

In the P.M. peak, the six trains stopping at both Salem and Beverly in Spring 2000 had a total of 413 North Station alightings on days with no Fleet Center events. This included 16 riders on a train that stopped only at Beverly and Salem and 15 counted boarding another train at those two stations. A train that picked up passengers only at Beverly had 31 boardings there. Overall count results show that Beverly Depot and Salem accounted for 62 North Station passengers on the three trains listed above, and for some portion of 295 riders on the other three trains who were not counted boarding at other stations. The imbalance between outbound A.M. peak and inbound P.M. peak ridership for the line as a whole is attributable to the much larger number of non-work trips usually found in the P.M. peak.

The Salem and Beverly stations are both located in old downtown business districts. These have many small businesses, but there are few large employers within walking distance of either station. Therefore, even after adjusting for school trips, the totals above probably include many non-work trips.

In addition to the train service, there are three MBTA bus routes between downtown Boston and Salem. At the time of the Spring 2000 rail counts, the bus and rail fares were equal, but the Fall 2000 fare increases make the bus fares lower than the train fares. The bus routes have much longer on-board times than the trains, but offer a much greater choice of boarding and alighting locations. It is also possible to transfer to several local bus routes at Salem Station, but train and bus schedules are not well coordinated.

At present, there is no through bus service between Boston and Beverly. MBTA bus Route 451 runs from Salem Station to North Beverly and serves downtown Beverly more directly than Beverly Depot does. All trains that stop at Salem also stop at Beverly Depot. For most passengers arriving in Salem on outbound trains, the extra time required to transfer to Route 451 and ride to downtown Beverly would cause more inconvenience than remaining on the train and walking from Beverly Depot to the main business district.

Readville

Readville is served by Fairmount Line trains terminating there and by some trains on the Franklin Line. Some of the latter use the Fairmount Line north of Readville and others use the Providence Main Line via Back Bay. Alighting counts were done at Readville in Spring 2000 for five of the six outbound A.M. trains stopping there. These had a total of 22 alightings, but 12 of them were on one trip which had a large number of students, and most of them boarded at Uphams Corner. The other four trips had only one to three alightings each. The trip for which alightings were not counted ran through to Walpole on the Franklin Line. It had a total of 24 passengers boarding at South Station, of which no more than four probably alighted at Readville. After adjusting for interzone and school trips, there would have been at most about 13 home-to-work trips from South Station to Readville on Fairmount Line trains. This would be a significant percentage increase but small absolute increase in reverse commuting to Readville since 1993. The survey that year found only five work-to-home trips from there in the P.M. peak.

Spring 2000 boarding counts were done at Readville for four of the five inbound P.M. peak trains stopping there. These had a total of 27 riders boarding there, with one train alone accounting for 23 of them. At least half of the latter were students going home from school. The train for which boardings were not counted at Readville originated there. It was observed arriving at South Station but had no alightings there. In a 1993 count that train had three offs at South Station. As on other lines, P.M. peak totals would include more non-commuting trips than A.M. peak totals, and are therefore less useful in measuring reverse commuting.

There are some work locations within walking distance of Readville Station, but the area is predominantly residential. This accounts for the relatively low reverse commuting activity despite relatively frequent service. It is also possible to reach the Readville area by even more frequent buses from Forest Hills and from Mattapan.

Stations with Five Outbound A.M. Peak Trains

The only stations in the system with five outbound A.M. peak trains as of Fall 2000 were Chelsea on the Newburyport/Rockport Line and Canton Junction and Route 128 on the Attleboro/Stoughton Line. Each of these stations had four inbound P.M. peak trains in Spring 2000, but Route 128 gained a fifth train in December.

Chelsea

Counts done in January 1999 showed a total of 56 outbound A.M. peak offs at Chelsea. The last three inbound P.M. peak trains had 63 boardings. (In the 1993 survey there were only two work-to-home trips from Chelsea in the P.M. peak.) The Spring 2000 counts did not include all trains at Chelsea, but the partial results indicate a decrease in ridership since 1999. This may be attributable to a change in the employment level at

the location that accounted for most of the riders in 1999, or in the travel modes of the workers there.

MBTA bus Route 111 (Woodlawn - Haymarket Station) passes close to Chelsea Station, and competes with the train for reverse commuters. The scheduled time on Route 111 from the vicinity of the Chelsea Station to Haymarket is about 13 minutes outbound in the A.M. peak and 14 minutes inbound in the P.M. peak. Scheduled reverse peak train times are 10 to 11 minutes outbound and 11 to 12 minutes inbound. Haymarket is closer than North Station to most downtown Boston destinations.

The Fall 2000 MBTA local bus fare of 75 cents applies on Route 111 regardless of the distance traveled. A local bus pass not including rapid transit transfer privileges reduces the cost to 60 cents if used for 21 round trips. The commuter rail fare from Chelsea to Boston is \$1.50 one way, dropping to 83 cents using a pass. The commuter rail pass is valid for transfer to the subway in Boston, but not valid on most buses.

Canton Junction

In the Spring 2000 counts, the five outbound A.M. peak trains stopping at Canton Junction had a total of 230 passengers boarding at South Station, Back Bay, or Ruggles, but this included 69 passengers who rode only from South Station to Back Bay. Route 128 accounted for another 79 off's, leaving only 82 riders going to Canton Junction or beyond. Based on the other possibilities, it is probable that no more than about 30 of these went to Canton Junction Station, which is in a predominantly residential area with limited employment opportunities. In the 1993 survey there were only three work-to-home trips from Canton Junction in the P.M. peak.

The four inbound P.M. peak trains stopping at Canton Junction in Spring 2000 had a combined total of 245 alightings at Back Bay and South Station. This included 68 riders who boarded at Back Bay, leaving 177 from more distant origins. Counts were done at Canton Junction for three of the four trains, and they showed a total of 35 boardings there. The other train had an estimated total of 20 boardings there, making the total 55. As at other stations, this would have included more non-repetitive trips than the outbound A.M. peak total.

At present there is no public transportation service other than the commuter rail line running directly to Canton Junction. A subsidized private carrier bus route from Mattapan runs through Canton Center, about one half mile from Canton Junction.

Route 128

Of the five outbound A.M. peak trains stopping at Route 128 in Spring 2000, four were the same as trains stopping at Canton Junction (discussed above) but each of these stations was served by one train that did not stop at the other. Alighting counts were done at least once for each of the five trains at Route 128. They showed 98 to 109 alightings. Individual trains had 15 to 30 alightings each. A December 2000 count

showed 87 alightings from the same five trains, with a maximum of 20 from any train. These would have consisted mostly of journey-to-work trips, as there are few non-work trip attractions within walking distance of the station. Development in the vicinity of the station consists mostly of low-rise industrial and office buildings. The 1993 survey found that only 13 of 1,255 inbound boarding passengers walked to the station from homes all day.

It is possible to transfer to Amtrak intercity trains at Route 128, but there would only be a convenient connection from one commuter train to one Amtrak train in the A.M. peak. The same Amtrak train could be boarded directly at South Station or Back Bay, where most of the boardings by passengers alighting at Route 128 apparently took place. The only intermediate stop not served by Amtrak trains was Ruggles, which had only three boardings on the train that had a good Amtrak connection at Route 128.

In the P.M. peak, Route 128 was served by two of the inbound trains that stopped at Canton Junction, by one train that left Canton Junction before 3:30, and by one that did not stop at Canton Junction at all. Boarding counts were done at Route 128 twice for one train and three times for another, but the other two trains were not observed there. Results varied widely from day to day, with one train having 25 to 56 boardings and the other having 14 to 24. The smaller numbers in each case were probably mostly homeward-bound trips by reverse commuters, as they were consistent with A.M. peak outbound alightings per train.

The 1993 survey found only 21 work-to-home trips from Route 128. Station access for these trips was about equally divided between walk-ins and drop-offs, and the latter may have included some by van.

There is no public transportation service to the Route 128 Station area from Boston other than commuter rail. In Spring 2000, the Neponset Valley Transportation Management Association sponsored a fixed minibus route from Route 128 Station to several work locations in Westwood, Norwood, and Dedham. There were six A.M. peak trips, four of which were intended to provide connections with outbound trains from Boston. Two of these had scheduled times of three minutes between train arrival and bus departure, but the other two had times of nine and 19 minutes. Scheduled running times from Route 128 Station to the most distant employment locations served exceeded 30 minutes. Scheduled train times from South Station to Route 128 on the connecting trains ranged from 16 to 20 minutes, so the time for the bus portion of many trips exceeded the time for the train portion.

In the P.M. peak the bus route had five trips, three of which nominally provided connections with inbound trains. The first two had scheduled connections of seven and four minutes, but were only usable by workers finishing their shifts at times between 3:00 and 4:00 P.M. The third trip served work shifts ending between 5:30 and 6:00, but required a 40-minute wait at Route 128 Station.

By the end of 2000, this route, with a modified schedule, was funded directly by some of the employers served. In December 2000 it was observed to have 52 transfer riders from the five outbound A.M. peak trains and three from one pre-peak train. Bus transfers accounted for 60% of the passengers alighting from all six trains combined. Walking was the second most popular choice at 23 (31%). Other egress modes (auto passenger, auto driver, taxi, and bicycle) accounted for only one or two outbound rail passengers each.

Stations with Four Outbound A.M. Peak Trains

Eight stations in the system each had four outbound A.M. peak trains in Spring 2000. These were Lynn and Swampscott on the Newburyport / Rockport Line, Malden Center and Melrose / Cedar Park on the Haverhill / Reading Line, and West Medford, Winchester, Mishawum, and Wilmington on the Lowell Line. Of these stations, only Mishawum had five inbound P.M. peak trains. West Medford and Winchester each had four. The rest had three each. Subgroups of stations served by the same trains are discussed together below to minimize duplication of information.

Lynn and Swampscott

In the A.M. peak, Lynn and Swampscott were both served by four of the six outbound trains that stopped at Salem and Beverly Depot. The Spring 2000 counts showed 153 North Station boardings on the four trains. Alighting counts were done at Lynn and Swampscott for two of these trains (Trains 61 and 103). They showed 11 alightings at Lynn and four at Swampscott. A November 2000 count of all four outbound A.M. peak trains at Lynn showed a total of 46 alightings there, with 16 of these being from the same two trains counted in the Spring. If ridership on all four trains increased at the same rate, the last two trains, which had 30 Lynn alightings in November, would have had only 21 in the Spring.

The two trains for which counts were not done at Swampscott (Trains 153 and 109) had higher total North Station ons than the trains that were counted, but also served more destinations, and had more alightings at Lynn in the November count. Based on the alighting patterns on the first two trains and North Station boardings on each of the four, it is reasonable to assume that all four trains combined had at most about 10 alightings at Swampscott. These could have included some non-work trips. For comparison, the 1993 survey found 17 work-to-home trips from Lynn Station and six from Swampscott in the P.M. peak. There were also nine school-to-home trips from Lynn in the mid afternoon, from the community college campus there.

In Spring 2000, the same three inbound trains served both Lynn and Swampscott in the P.M. peak. These had a total of 329 North Station alightings on days with no Fleet Center events. No boarding counts were done at Swampscott. A count on one train found 22 boardings at Lynn. This was higher than the outbound alightings observed for any train at Lynn in the A.M. peak, reflecting more non-work trips in the P.M. peak.

Lynn Station is located in a densely developed older urban area, and MBTA bus connections to points throughout Lynn and surrounding communities can be made there. There are also several MBTA bus routes to Lynn from downtown Boston, with fares slightly lower than those of the trains.

In Swampscott the station is about one half mile from the main business district, but there are no large employers there. Several MBTA bus routes from Boston pass through Swampscott, but do not run directly to the station.

Malden Center and Melrose/Cedar Park

Malden Center is the first stop from North Station on the Haverhill / Reading Line, and Melrose / Cedar Park is two stops further out. In the A.M. peak, the same four outbound trains stopped at both station in Spring 2000. The counts then included boardings and alightings for all A.M. peak trains at Malden, but not for individual stations further out on this line. The four outbound A.M. peak trains had a total of 64 North Station boardings. None of them had any alightings at Malden, but 17 passengers boarded there. These trains also had no Malden alightings in the 1997 and 1996 CTPS counts.

In the December 1997 counts these trains had 54 boardings at North Station and ten at Malden and had two alightings at Melrose / Cedar Park. In December 1996 the respective totals were 60, five, and one. It is reasonable to assume that the level of A.M. peak outbound travel to Melrose / Cedar Park is still negligible.

In the P.M. peak, three inbound trains stopped at Malden, and two of these also stopped at Melrose / Cedar Park. A third train stopping at Melrose / Cedar Park left Malden at 6:31. Counts were done at Malden for all of these trains in 2000, but showed only one passenger boarding there. The 1997 count also had only one inbound P.M. peak Malden Center boarding, but the 1996 count had four. The 1993 survey did not find any reverse commuting trips at Malden Center.

The 2000 counts did not include P.M. peak activity at stations north of Malden. North Station alightings from the three trains stopping at Melrose / Cedar Park totaled only 27. This was lower than usual, because passengers from some stations were being bused due to track work. The December 1997 counts had 76 North Station alightings and five Melrose / Cedar Park boardings for the same trains. In 1996, with a slightly different schedule, four inbound P.M. peak trains stopped at Melrose / Cedar Park, and they had two ons there. North Station offs for the four inbound trains totaled 88. The 1993 survey found only one P.M. peak inbound work-to-home trip at Melrose / Cedar Park. From the results above, it is reasonable to assume that the level of P.M. peak reverse commuting between Melrose / Cedar Park and Boston is still negligible.

Malden Center Station is in an older downtown area with a fairly high number of work locations, but the Orange Line provides more frequent rapid transit service from more origins. Except for pass users, the Orange Line also offers lower fares. The commuter rail and Orange Line pass fares are equal. The results at Malden Center support the

conclusion that to attract reverse commuters, commuter rail must not merely provide frequent service to areas with substantial employment opportunities. It must also be the most convenient and economical mass transit alternative available to access the same work locations.

The Melrose / Cedar Park Station is in a predominantly residential area, with a few small businesses nearby. It is not served directly by any bus routes. It is, however, about one third of a mile from Main Street, which is used by several MBTA bus routes that have Orange Line connections at Oak Grove and Malden Center.

West Medford and Winchester

In the A.M. peak, the same four outbound trains stopped at West Medford and Winchester in Spring 2000, and three of these were among the trains stopping at Mishawum and Wilmington. In the counts then, the four trains had 206 boardings at North Station. Counts for three of these trains showed a combined five offs at West Medford, and counts for two trains showed a combined 15 offs at Winchester. The December 1996 counts found five offs at West Medford and 13 at Winchester from four trains with 177 North Station boardings. Based on the observed ridership changes at stations where counts were done in both 1996 and 2000, reasonable maximum estimates of total outbound A.M. peak offs in 2000 would be 10 at West Medford and 25 at Winchester. Not all of these would have been work trips. For comparison, the 1993 survey found only seven P.M. peak work-to-home trips from Winchester and two from West Medford.

In the P.M. peak, the same four inbound trains stopped at West Medford and Winchester. All four also stopped at Mishawum, but the first one left Wilmington before 3:30. On most days non-work trips on this line in the P.M. peak greatly outweigh homeward reverse commuting trips. Therefore, P.M. peak counts are less useful than A.M. peak counts in estimating reverse commuting ridership. In Spring 2000, the last three of the four inbound P.M. peak trains had a total of 10 riders boarding at West Medford. Based on North Station alightings and 1996 counts, the first train probably had no more than three West Medford ons. The last two of the four trains had 29 ons at Winchester, but the first two most likely had no more than about five each there.

Winchester Station is located in an old town center with limited employment opportunities. Access from Boston to Winchester Center is also provided by a combination of the Orange Line to Wellington and bus Route 134. Travel times are longer via this combination, but the Orange Line can be accessed directly from many more Boston residential neighborhoods than the commuter rail line can. The total fare is also significantly lower via the Orange Line and bus combination. The commuter rail fare alone (i.e. excluding North Station access) in Spring 2000 was \$2.25 one way. A monthly pass cost \$64.00, reducing the fare to about \$1.52 for the average pass user. The Orange Line and bus had a combined one-way fare of \$1.45. A monthly pass for these services cost \$46.00, resulting in a cost of about \$1.10 per ride. The Fall 2000 fare

increase has widened the difference between commuter rail fares and combined Orange Line and bus fares, improving the relative attractiveness of the latter.

Alternate access to West Medford is provided by a combination of the Orange Line to Sullivan Square and bus Route 95, by a combination of the Red Line to Davis Station and bus Route 94, or by express bus Route 326 from Haymarket. The commuter rail fare alone in Spring 2000 was \$1.25 one way. A monthly pass cost \$27.00, reducing the average fare to about \$0.64 for the average pass user. The combined rapid transit and bus fares were the same as stated above to Winchester. The express bus fare was \$1.50, which could be reduced to about \$1.10 using a pass. Therefore, commuter rail was the least expensive alternative, especially for pass users. The Fall 2000 fare increase makes the absolute fare saving of commuter rail versus other alternatives to West Medford slightly greater, but reduces the percentage difference for pass users slightly.

Mishawum and Wilmington

In the A.M. peak, Mishawum and Wilmington were served by the same four outbound trains in Spring 2000. The counts then included only very limited observations of activity at these stations. Counts for all four trains were done at Mishawum in December 2000, and showed a total of 81 alightings there. The same four trains had 248 North Station boardings in the Spring 2000 counts. Disregarding local riders, if Mishawum alightings did not change during the year, they would have accounted for about 33% of these. Overall Mishawum alightings in December 2000 were slightly lower than the 86 total found in a December 1996 count. Alightings increased from the first two trains, but decreased from the other two. In the 1996 count, these trains had only 156 North Station boardings, with Mishawum alightings equivalent to 55%, so ridership to other stations served by these trains has increased. The 1993 survey found 81 work-to-home trips from Mishawum in the P.M. peak.

Mishawum is within walking distance of several modern office and industrial parks, and has private shuttle van connections to others. The December 2000 counts showed that of the 81 riders alighting from outbound A.M. peak trains, 59 (73%) left the station on foot, 12 (15%) transferred to an employer-sponsored van going to a company in Burlington, and 5 (6%) took taxis. At least some of the latter used fare vouchers from a company in Wilmington. Of the others 3 (4%) were picked up in private autos and 2 (2%) transferred to Logan Express buses. The Logan Express passengers would not have been commuters, and those picked up in autos may not have been either.

Reverse commuting service from downtown Boston to Mishawum is also provided by MBTA express bus Route 355. The bus and train monthly pass fares are the same. This route has been operating only since September 1998. CTPS counts from the Spring of 1999 found only six outbound and seven inbound riders on the two trips each way on Route 355. The Mishawum Station stop was used by only three riders outbound and one inbound.

A new station on the Lowell Line, Anderson / Woburn, about one mile north of Mishawum, opened on April 30, 2001. Most trains on the line began stopping there instead of at Mishawum, but three of the four outbound A.M. peak trains also continued to stop at Mishawum for the benefit of reverse commuters.

In December 1996, Wilmington Station accounted for 14 offs from the four A.M. peak trains that had 156 North Station ons. A proportional share of the growth at stations other than Mishawum would have raised Wilmington offs to about 30 in Spring 2000. For comparison, the 1993 survey found only seven P.M. peak work-to-home trips from Wilmington.

In the P.M. peak Wilmington Station was served by three inbound trains in Spring 2000. Mishawum was served by all of these and two others. In the 2000 counts, the three trains stopping at both stations had 308 offs at North Station and the other two serving Mishawum had another 102, but these would have included many non-work trips. Starting April 30, 2001, only three inbound P.M. peak trains stopped at Mishawum.

Wilmington Station is in an area of small businesses with limited employment opportunities. There is no public transportation service other than commuter rail linking Wilmington with Boston. (Trains on the Haverhill / Reading Line stop at North Wilmington Station, but it is too far from downtown Wilmington to compete for the same riders, and it does not have reverse commuting service.)

Stations with Three Outbound A.M. Peak Trains

Twenty-nine stations in the commuter rail system each had three outbound A.M. peak trains in Spring 2000, making this the second most common service level. Within this total were several subgroups of stations on the same lines and served by the same trains. In such cases they are discussed together to minimize duplication of information.

Newburyport/Rockport Line

River Works Station was the only one on the Newburyport / Rockport Line with exactly three outbound A.M. peak trains. It is located within a secured area at the General Electric complex in Lynn and is used almost exclusively for work trips by G.E. employees. The Spring 2000 counts included alightings at River Works from two of the three trains, each of which had four offs there. Based on total North Station boardings, the third train would also have had about four offs at River Works, making a total of 12.

In P.M. peak hours, five inbound trains stopped at River Works, but Spring 2000 boarding counts were done there for only two of them. Of these, one had three ons and the other had none. This suggests that total inbound ons there would have been no greater than total outbound A.M. peak offs.

Because of reductions in defense contracts, total employment at the G.E. complex has fallen substantially in recent years. It does not appear that increasing the number of trains stopping at River Works would improve ridership significantly.

It is also possible to travel from downtown Boston to the River Works complex via MBTA bus routes 450, 455, or 459. These have lower fares and greater service frequencies than the train, but have much more variation in both scheduled and actual running times.

Haverhill/Reading Line

Melrose Highlands, Wakefield, and Reading on the Haverhill/Reading Line were served by the same three outbound A.M. peak trains in Spring 2000. Wyoming Hill was also served by two of these trains and by one that reached the other three stations after the end of the A.M. peak. In the Spring 2000 counts, outbound A.M. peak boardings and alightings were not counted at any individual stations north of Malden Center. In the December 1997 and December 1996 counts, there were no outbound A.M. peak alightings from any train stopping at Wyoming Hill. That station is in a predominantly residential area that can also be reached by three MBTA bus routes from Oak Grove or Malden. Therefore, it can be assumed that there was still little or no reverse commuting by train there in 2000.

The three outbound A.M. peak trains stopping at Melrose Highlands, Wakefield, and Reading had a combined total of 56 boardings at North Station and 16 more at Malden Center, with no alightings at the latter in Spring 2000. In the December 1997 counts, the same three trains had 51 ons at North Station and nine at Malden. None of these trains had any offs at Melrose Highlands, but there were 18 offs at Wakefield and 24 at Reading. As discussed in a previous section of this chapter, the number of A.M. peak outbound offs at Melrose/Cedar Park, where the same trains also stopped, was negligible.

All of the net increase of 12 North Station and Malden boardings between 1997 and 2000 was on two trains that terminated at Reading. Since there is no reason to believe that ridership had increased at the stations in Malden or Melrose, all of the increase in offs must have been at Wakefield or Reading. If divided in the same proportion as the 1997 counts, the gains would have raised total A.M. peak outbound offs to 22 at Wakefield and 32 at Reading.

In the P.M. peak, three inbound trains stopped at Reading and Wakefield and four at Melrose Highlands. Two of the latter also stopped at Wyoming Hill. It was not possible to get representative counts for these trains in Spring 2000 because of substitute busing required by a track maintenance project. In December 1997 the two trains stopping at Wyoming Hill had a total of two ons there. The four trains stopping at Melrose Highlands had a total of five ons there. The three P.M. peak trains were boarded by 23 riders at Wakefield and 27 at Reading. As at other stations, there would be more non-repetitive trips among inbound P.M. peak ons than among outbound A.M. peak offs.

The 1993 survey found only nine P.M. peak work-to-home trips from Wakefield to North Station, and none of these had final destinations in Boston. From Reading there were only five work-to-home trips to North Station, but four of them had final destinations in Boston.

The Wakefield and Reading stations are both located in old downtown areas with many small businesses but few individual large employers nearby. Both areas are served by MBTA bus Routes 136 and 137 from the Orange Line at Oak Grove and Malden.

Lowell Line

In Spring 2000 North Billerica and Lowell on the Lowell Line were served by the same three outbound A.M. peak trains (Trains 305, 307, and 309). Wedgemere was served by two of the three, (307 and 309) and by a third that reached North Billerica and Lowell after the end of the A.M. peak (Train 311). Counts then for the two trains serving all three stations showed a total of 111 ons at North Station. Eight passengers alighted from these trains at Wedgemere, and it is reasonable to assume that all or most of them boarded at North Station. An alighting count was not done at Wedgemere in 2000 for the third outbound A.M. peak train that stopped there, but in the 1996 count that train had no offs there. The 1993 survey found no P.M. peak work-to-home trips from Wedgemere to North Station.

Wedgemere Station is in a predominantly residential area, so the eight outbound A.M. peak offs may not have included any reverse commuters. There are no transit alternatives other than commuter rail for travel from Boston to Wedgemere Station itself, but bus route 134 from the Orange Line at Wellington passes within one third of a mile on the east, and Route 350 from the Red Line at Alewife passes within less than one mile on the west.

Based on the distribution in the 1996 counts, Trains 307 and 309 would have had a total of about 60 offs at Lowell and one at North Billerica in 2000, but some would have been interzone trips. Train 305 had 48 ons at North Station in 2000, of which at most 15 to 20 could still have been on board beyond Wilmington. In 1996, the same train had only three offs at North Billerica and eight at Lowell from all origins. Of these, at most nine could have come from Boston. In conclusion, it appears that there were still no more than about five A.M. peak reverse commuting trips from Boston to North Billerica, and no more than about 65 from Boston to Lowell in 2000. For comparison, the 1993 survey found 24 work-to-home trips and six school-to-home trips from Lowell to North Station on P.M. peak trains. Another nine school-to-home trips outside P.M. peak hours could also have been return halves of outbound A.M. peak trips. The survey also showed only two P.M. peak work-to-home trips from North Billerica to North Station.

In the P.M. peak, four inbound trains stopped at Lowell and North Billerica. All four also stopped at Wedgemere, but the last one arrived there after the end of the P.M. peak span. These four trains had a total of 334 alightings at North Station, compared with about 275 boardings at North Station on all outbound A.M. peak trips. The 2000 counts

included little information on P.M. peak inbound boarding locations. Based on the boarding distribution in 1996, P.M. peak inbound ones in 2000 would have totaled 120 to 170 at Lowell and 20 to 30 at North Billerica.

Lowell Station is in the center of an old downtown area with many employers, but only a small percentage of these are within convenient walking distance of the station. Only one in four of the survey passengers making work-to-home trips from Lowell to North Station reported using walk-in access. North Billerica Station is in a predominantly residential area. The nearest large employment site is the office building of Guilford Rail System, but it is beyond convenient walking distance. There are no transit alternatives other than commuter rail for travel from Boston to Lowell or Billerica.

Fitchburg Line

In Spring 2000 Porter Square, Waltham, Brandeis/Roberts, and Concord were the only stations on the Fitchburg Line served by three outbound A.M. peak trains, and all of them were served by the same trains (Trains 453, 455, and 417).

In the P.M. peak, Porter Square, Waltham, Brandeis/Roberts, and Concord were all served by three inbound trains. (Trains 424, 466, and 468). In March 2000 counts, these three trains had a total of 203 alightings at North Station, compared with a total of 211 boardings on the three outbound A.M. peak trains. This contrasts with the pattern on other lines, where P.M. peak inbound ridership usually exceeds A.M. peak outbound trips. This is partly attributable to the higher level of student ridership on the Fitchburg Line, because students often return from school before the start of the P.M. peak. Some riders apparently use the Fitchburg Line outbound but return by other means.

Porter Square

Alighting counts at Porter Square show substantial variation, indicating that many are non-repetitive trips. Counts taken in January 1999 showed a total of 39 outbound offs at Porter from all three A.M. peak trains, with none of these from the first train. Counts from March 2000, which included only the first two trains, showed 40 alightings from those alone. At least 10 more were estimated to alight from the third train. The 1993 survey results indicated that about half of the A.M. peak outbound alightings at Porter were by passengers who transferred to Fitchburg Line trains from other commuter rail routes at North Station. With a similar proportion, the upper limit on A.M. peak home-to-work trips from Boston to Porter Square in 2000 would have been about 25. (The overall survey response rate from passengers boarding at Porter Square was very low, and included no P.M. peak surveys.)

Porter Square Station is in a densely developed commercial area, but there are few individual large employers nearby. Porter Square can also be reached from downtown Boston via the Red Line, which offers much more frequent departures, more boarding locations in Boston, and more alighting locations in Cambridge. The Green and Orange lines both provide connections from North Station to the Red Line. A 1997 CTPS count showed that in the same span of hours that the three outbound A.M. peak Fitchburg

trains arrived, 294 passengers alighted from outbound Red Line trains at Porter Square. Boarding points of these passengers were not determined.

Waltham

At Waltham Station in the March 2000 counts, 70 passengers alighted from the first two outbound A.M. peak trains. The only other available count at this station was done in October 1994. It shows only 28 alightings from the first two trains and another six from the third. With similar growth since 1994, the third train would have had 15 offs in 2000, raising the combined total to 85. Waltham passengers on all three trains could have boarded at either North Station or Porter Square, and on the first two trains, Waltham passengers could also have boarded at Belmont or Waverley. Based on the relative number of boardings at North Station and Porter and on Porter alightings, about half of the Waltham passengers, or 43, would have boarded at North Station. This may have included some transfers from other commuter rail lines.

The 1993 survey results showed 19 inbound P.M. peak work-to-home trips from Waltham Station to North Station, including 17 with final destinations in Boston. The same trains carried only seven riders from Waltham to North Station for other purposes. This suggests that outbound A.M. peak offs at Waltham by passengers boarding at North Station would also have been predominated by work trips.

Waltham Station is in an older urban area, but there are no individual large employers in the immediate vicinity. MBTA bus Routes 505, 553, 554, 556, and 558 all provide through service between Waltham Station and downtown Boston, and have schedules suitable for reverse commuting. The bus running times are longer than the train times, but the buses offer much more frequent departures and serve more Waltham destinations directly. The single-ride and cash fares on Route 505 are the same as those on the train, but the other bus routes have lower fares. As discussed further in chapter 5, the industrial areas along Route 128 in Waltham are also served by an express bus route from downtown Boston and by connecting services from the Red Line. There is also a van service from near Waltham Station to one of the Route 128 office parks. A new city-sponsored bus network with routes radiating from Waltham Center began operating at the end of December 2000. It was possible to transfer to some of the routes from trains, but the connections were not scheduled specifically for reverse commuting.

Brandeis/Roberts

At Brandeis/Roberts the March 2000 counts included only the second of the three outbound A.M. peak trains (Train 455), from which there were 59 offs. This was believed to be lower than usual because Brandeis University was on Spring break at the time. An October 1994 count showed 73 Brandeis/Roberts alightings from this train, including 57 passengers who headed toward the university. Alightings there from the three trains at that time totaled 129, including 94 going toward the university. Most of the 35 who left in the opposite direction appeared to be heading for a nearby office park, and were presumably making work trips. Some of those going toward the university may also have been going to work.

Because of the large student population in the Porter Square area, a drop in student alightings at Brandeis/Roberts would be expected to result in reduced boardings at Porter. Train 455 boardings there increased from 69 in January 1999 to 85 in March 2000, but the status of Brandeis during the earlier counts was not recorded. The 1993 survey results showed a total of 20 P.M. peak work-to-home trips from Brandeis/Roberts to North Station, including 13 with final destinations in Boston.

As noted above, major employers within walking distance of Brandeis/Roberts Station include the Brandeis University complex to the north and the University Office Park to the south. A few additional low-rise offices and industrial plants are located along Technology Drive within a half mile to the west. Most of the large employers in Waltham that would be likely to attract commuters from Boston are located in office parks along Route 128/I-95 that do not have convenient access from either Brandeis/Roberts or Waltham Station.

Through service to Brandeis/Roberts Station from downtown Boston is also provided by MBTA bus Route 553. The buses have longer running times than the trains, but offer some different arrival times and serve more destinations directly. The buses also have lower fares. Like the trains, however, they do not serve most of the Route 128 employers.

Concord

CTPS has not done any passenger counts at Concord Station. The 1993 survey indicated that there were only five work-to-home trips from Concord to North Station all day. The largest known reverse commuting destination served by Concord Station is Concord Academy. Students have to take the first outbound train (Train 453) to arrive in time for classes there. This is also the train used by students going to the Cambridge School of Weston, near Kendal Green Station on the Fitchburg Line. The March 2000 count showed a total of 82 riders still aboard Train 453 as it left Waltham. Allowing for alightings at Brandeis/Roberts, about 60 of these riders would have continued past there. The Cambridge School was reportedly on break at the time of this count, so about 55 riders boarding at stations up to Waltham would be expected to have remained on board past Kendal Green. Their destinations could have included Lincoln, Concord, West Concord, or South Acton. Deducting boardings after Porter, ridership to Concord Station on this train from Boston and Cambridge combined could not have been much greater than 50 and was probably less. The 1993 survey results indicated that of the Concord Academy students returning home in the P.M. peak to stations from Brandeis/Roberts east, only about 10% went as far as North Station.

Train 455 had more total boardings at North Station and Porter Square than Train 453, but it is also usually the train most heavily used for travel to Brandeis/Roberts. After leaving that station, there were 56 riders still on board going to all subsequent stations, or slightly less than the estimated number on Train 453. Train 455 would have had few, if any Concord Academy students, however. Train 417 usually has the lowest total ridership of the three outbound A.M. trains, and it is the first train of the day to run

through to Fitchburg. Therefore, alightings at individual stations between Porter and South Acton would be expected to be much lower than those from the two earlier trains.

A reasonable maximum estimate of current home-to-work trips from Boston to Concord Station would be 15. The 1993 survey found only five P.M. peak work-to-home trips from Concord Station to North Station, all with final destinations in Boston.

Concord Station is in a small commercial district surrounded by low-density residential development. There are no individual large employers within convenient walking distance of the station. Some newer office buildings are located on state Route 2, which bypasses the town center where the station is located. The only alternate public transportation service between Concord and Boston is provided by a private carrier bus route that runs only one round trip per day, scheduled for commuting to work in Boston.

Framingham/Worcester Line

On the Framingham / Worcester Line, the only station that had three outbound A.M. peak trains at the time of the Spring 2000 counts was Wellesley Hills (served by Trains 505, 507, and 559). These counts showed 32 offs there from the first two trains on one day, but only 22 on another day, with the difference probably attributable to occasional riders. A November 1994 count found a total of 36 outbound alightings from the same two trips, including nine high school age students. Wellesley Hills is the first stop after Boston on these trains, so all of the alightings must have been by through riders. Counts for the third train were done only at South Station and Back Bay in 2000, but given the lower total boardings there compared with those on the earlier trains, Wellesley Hills alightings are estimated to have been in the range of five to seven.

In the P.M. peak only two inbound trains stopped at Wellesley Hills. These had a total of 20 boardings there, in the same week that the 32 outbound offs were observed. Student trips returning before the start of the P.M. peak could explain this difference. A third inbound P.M. peak train stopping at Wellesley Hills was added as of April 30, 2001.

Overall, the 2000 count results imply that there were no more than 20 home-to-work trips from South Station or Back Bay to Wellesley Hills. The 1993 survey showed a total of 26 work-to-home trips from Wellesley Hills to Back Bay or South Station, but only six of these had final destinations in Boston.

Wellesley Hills Station is in a small older business district, with no major employers within convenient walking distance. There is currently no direct alternate public transportation service between Boston and Wellesley Hills. Until the Fall of 1999 a private-carrier bus route from Boston to Worcester via state Route 9 included one trip in each direction that would have been suitable for reverse commuting between Boston and Wellesley Hills. The bus fares were slightly lower than the train fares, but the bus was slower and seldom carried Wellesley Hills riders.

Needham Line

On the Needham Line, West Roxbury Station and all four stations in Needham were served by the same three outbound A.M. peak trains in Spring 2000. The counts then did not include passenger activity at any of these stations, but did show total ons and offs at South Station and Back Bay. On a composite count day, the three trains carried a total of 95 riders leaving Back Bay. Each station between Back Bay and West Roxbury was served by two of the three trains, so not all of the 95 would have gotten even as far as West Roxbury. Of the 95 riders, 59 were on the first two trains. In the 1994 counts, those two trains carried 69 riders, so there has been relatively little change since then. In those counts, only three riders alighted at stops prior to West Roxbury, but 19 more boarded at those stops. West Roxbury had the largest total number of alightings, at 44. All of these were students, with 37 from the earlier train alone.

It is also possible to travel from downtown Boston to the vicinity of West Roxbury Station using a combination of the Orange Line and MBTA bus routes 35, 36, or 37. This combination has slower travel times, but much more frequent departures and lower fares than the train. The buses also offer direct service to more destinations. There are many small businesses within convenient walking distance of the West Roxbury Station, but few individual large employers.

Hersey and Needham Junction each had 12 alightings in the 1994 counts, but only one of the trains stopped at Hersey then. Most of the alightings there were also by students. Needham Center and Needham Heights, which were both then served by only the earlier train, had seven and ten offs, respectively.

There is no alternate public transportation service to Hersey Station. The station is in a predominantly residential area with a few small businesses nearby. Needham Junction, Needham Center, and Needham Heights are all served by MBTA bus Route 59, which connects with the Green Line at Newton Highlands. The Green Line and bus combination has slower travel times, but more frequent departures and lower fares than the train. The buses also offer direct service to more destinations. There are many small businesses within convenient walking distance of the outer three Needham Line stations, but few individual large employers.

In the P.M. peak, West Roxbury and the four stations in Needham were each served by three inbound trains in Spring 2000. No counts of ons and offs at any of these stations were done either then or in 1994. In 2000, the three trains serving all of these stations had a total of 133 alightings at Back Bay or South Station, excluding local travel between those two. This was 40% higher than the outbound A.M. peak ridership on the line. As on most other lines, the inbound P.M. peak total would have included more non-repetitive riders than the outbound A.M. peak figure.

In conclusion, in 1994 there was very little reverse commuting to work on the Needham Line. This was apparently still the case in 2000, regardless of assumptions about the proportion of ridership accounted for by students. A reasonable estimate would be five

to ten home-to-work trips from Boston to each of the stations that have three outbound A.M. peak trips.

Franklin Line

The ability to provide reverse commuting service is more constrained on the Franklin Line than on most of the other lines because of the length of the route, the amount of single track, and the number of peak-direction trains needed to meet demand. Consequently, the only station on the line with three outbound A.M. peak trains in 2000 was Norwood Central. The earliest of these, Train 793, was routed via the Fairmount Line, and stopped only at South Station, Readville, Norwood Central, and Walpole. A March 2000 count showed 24 boardings at South Station. Alightings were not counted by station. The preceding and following Fairmount Line trains had only one and four riders alighting at Readville, so it can be assumed that most of the riders on Train 793 continued to either Norwood Central or Walpole.

The second outbound A.M. peak trip, Train 795, was also routed via the Fairmount Line. It stopped at South Station, Dedham Corporate Center, and Norwood Central and then ran local to Forge Park. An April 2000 count found 37 riders boarding at South Station and 12 alighting at Dedham Corporate Center, leaving 25 for all six subsequent stations combined.

The third outbound A.M. peak trip, Train 735, stopped at South Station and Back Bay, then ran non-stop to Norwood Central where it terminated. An April 2000 count on this train found 18 passengers going to Norwood Central, including seven from South Station and 11 from Back Bay. Since this was the only one of the three trains stopping at Back Bay, it probably carried more riders from there than it would have if the other two trains had stopped there. Overall it is reasonable to assume that at most about 35 reverse commuters rode from Boston to Norwood Central on all A.M. peak trains combined. (Train 735 began also serving Norwood Depot as of April 30, 2001.)

In the P.M. peak, the only Franklin Line stations with three inbound trains in Spring 2000 were Norwood Central and Dedham Corporate Center. These trains (720, 796, and 798) all ran via the Fairmount Line, so they did not stop at Back Bay. Spring 2000 counts found a total of 178 passengers alighting from these trains at South Station, compared with 79 riders on outbound A.M. peak trains. As on most lines, the P.M. peak total would include more non-commuting trips. Trains 720 and 798 were through trips from Forge Park. Train 796 was a Norwood Central short-turn with only one intermediate stop at Dedham Corporate Center. Train 720 carried the largest share of the riders on the three trains, with 103. The on-board count began at Readville, and all but one passenger was on board prior to that, but no information on boardings by stop was obtained.

Train 796 had a total of 33 riders, with 20 from Norwood Central and 13 from Dedham Corporate Center. Train 798 had 42 passengers alighting at South Station. Ons and offs were counted at all stations from Norwood Central in. Of these riders, 13 boarded at

Norwood Central, six at stations closer to Boston, and 23 at stations further from Boston. With a similar boarding distribution, Train 720 would have had about 32 ons at Norwood Central, raising the P.M. peak total there to 66.

The 1993 survey found only four P.M. peak work-to-home trips from Norwood Central to stations in Boston, but all had final destinations in Boston. Norwood Central Station is in an old business district, but most of the larger individual employers within the town are beyond convenient walking distance from the station. Alternate public transportation from Boston to Norwood is provided by a combination of the Orange Line and MBTA bus Route 34E. This combination offers much more frequent service and substantially lower fares than the train.

Attleboro/Stoughton Line

Five stations on this line had exactly three outbound A.M. peak trains in Spring 2000. Canton Center and Stoughton were served by trains 905, 907, and 909. All three stopped at both South Station and Back Bay and at Canton Junction. Trains 907 and 909 also stopped at Route 128. Three other trains (Trains 803, 831, and 805) all stopped at Ruggles, Mansfield, and Attleboro.

Canton Center and Stoughton

A composite Spring 2000 count indicated that Train 905 carried no more than 20 riders a day for Canton Center, Stoughton, and Canton Junction combined. Complete boarding and alighting counts on Train 907 showed 22 riders on board leaving South Station, but only one of these rode to Canton Center and two to Stoughton. Another four went to Canton Junction and 15 to Route 128. These splits suggest that Train 905 would have had at most about 12 riders going to Stoughton and three to Canton Center. Train 909 had 24 passengers on board leaving Back Bay, including 15 going to Route 128 and nine continuing further. Based on the splits on Train 907, this would have included about five riders for Stoughton and one for Canton Center. Overall it appears that there were no more than 20 A.M. peak reverse commuters to Stoughton and no more than five to Canton Center.

During P.M. peak hours, only one inbound train (Train 920) served Stoughton, but Train 918 left there at 3:18. Canton Center was served only by Train 978. In Spring 2000, passenger counts for Train 918 were done only at Back Bay and South Station. There were 82 passengers on board approaching Back Bay. Possible boarding points in addition to Stoughton were Canton Junction, Route 128, and Hyde Park. A 1994 count for Train 918 at Hyde Park found only two boardings there. Based on the ridership change on Train 920 at Hyde Park between 1994 and 2000, Train 918 would be expected to have had no more than five boardings there in 2000, leaving 77 at the other three stations. Divided evenly, the average would have been 26 per station.

A Spring 2000 on-board count on Train 920 showed 15 boardings at Stoughton. Combined with the estimate for Train 918 this would have made a total of 41 riders, compared with the estimated 20 outbound in the A.M. peak.

Train 978 was run mostly to return equipment to Boston from outbound Train 977. A Spring 2000 count found 11 riders boarding at Canton Center, compared with an estimated five outbound A.M. peak riders.

The 1993 survey showed a total of eight P.M. peak work-to-home trips from Stoughton to the Boston stations, but only four of these had final destinations within Boston. Stoughton Station is within an old downtown area, but there are few individual large employers within convenient walking distance. At present, there is no other public transportation alternative for travel between Boston and Stoughton.

At the time of the 1993 survey, no inbound P.M. peak trains stopped at Canton Center, and no work-to-home trips were found boarding at that station at any time of day. The station is in a predominantly residential area, and the nearest large employer is equally close to Canton Junction Station.

Alternate public transportation to Canton Center is provided by a subsidized private-carrier bus route from Mattapan Station. To get to Mattapan from downtown Boston riders would use either a combination of the Red Line and the Mattapan High Speed Trolley Line or the Orange Line and a local bus. For a monthly pass user, this would be slightly less costly but much more time-consuming than riding the train. In the morning, the bus has three outbound trips, the same as the train, but with slightly different arrival times at Canton Center. In the P.M. peak, the bus offers three departures compared with only one for the train.

A new bus route started in 1999 provides reverse commuting service from downtown Boston to the Canton Commerce Center, which is beyond convenient access distance from Canton Center Station. Spring 2000 counts showed a total of only seven riders on the three outbound A.M. peak trips on the bus route.

Ruggles, Mansfield, and Attleboro

The three outbound A.M. peak trains serving Ruggles, Mansfield, and Attleboro, in Spring 2000 were Train 803 to Providence, Train 832 to Attleboro, and Train 805 to South Attleboro. The Spring 2000 counts included boardings and alightings at some or all stations for each of these trains. Effective April 30, 2001, Mansfield gained a fourth outbound A.M. peak train, leaving South Station at 6:35 and due at Mansfield at 7:06. This train runs non-stop between Back Bay and Mansfield, and its main purpose is to provide equipment for a new inbound local train leaving Mansfield at 7:21. At this writing it is too soon to measure ridership on the new trains. (They are numbered 831 outbound and 832 inbound. The trains that used these numbers in 2000 have been renumbered 833 and 834. The old numbers are used in the discussion below.)

At Ruggles Station, most of the outbound alightings were from Train 803, due at 6:51 A.M. Counts for this train on four different days in Spring 2000 showed offes varying between 10 and 20. These probably included transfers from inbound Franklin Train 702, which didn't stop at Ruggles but had a scheduled five-minute connection with Train 803 at Back Bay Station. Such transfer passengers would not be reverse commuters. The

Orange Line also provides a direct link between Back Bay and Ruggles. Passengers making the latter trip can use either a rapid transit pass or a commuter rail pass on either service. Variation in daily ridership would depend in part on when passengers boarding at Back Bay arrived there relative to departures of Train 803 and Orange Line trains.

Trains 831 and 805 each had one alighting or none at Ruggles in two observations each. Train 831 did not make a good connection at Back Bay with any inbound trains that did not stop directly at Ruggles. Train 805 could theoretically have served as a connection from inbound Franklin Line Train 738, but that connection was so close that it may have been missed on the count days. Orange Line counts at Ruggles from 1997 show total outbound alightings there being slightly lower in the 15-minute intervals in which Trains 831 and 805 were due in 2000 than in the one in which Train 803 was due. The much larger differential in the commuter rail figures reinforces a conclusion that Train 803 offs were largely transfers from Train 702.

Because of track and platform layout constraints, no inbound commuter rail trains on any route stop at Ruggles during P.M. peak hours. In Spring 2000, all outbound P.M. peak Attleboro/Stoughton, Needham, and Franklin Line trains stopped directly at Ruggles, except for one Franklin train that ran via the Fairmount Line and also bypassed Back Bay. Therefore, there was no reason for outbound riders to start their trips by traveling inbound to Back Bay and transferring. Any passengers who made actual reverse commuting trips from Back Bay to Ruggles via commuter rail in the A.M. peak could have made their return trips on the Orange Line.

A complete on-board count on Train 803 in March 2000 found 71 riders on board departing Ruggles. There were 10 offs at Mansfield and 13 at Attleboro. All or most of these would have boarded at one of the Boston stations, but it is possible that some interzone riders were included.

A partial on-board count on Train 831 showed 49 riders after Ruggles. The last alighting count was done at Route 128, where there were 20 offs, leaving 29 going to the remaining three stops at Canton Junction, Mansfield, and Attleboro. Based on the distribution of offs from Train 803, Mansfield and Attleboro would each be expected to have accounted for 10 to 15 offs from Train 831.

Similarly, a partial on-board count on Train 805 showed 50 riders after Ruggles. The last alighting count was done at Route 128, where there were 23 offs, leaving 27 for the remaining five stops at Canton Junction, Sharon, Mansfield, Attleboro, and South Attleboro. Based on the distribution of offs from Train 803, Mansfield and Attleboro would each be expected to have accounted for at most 10 offs from Train 805. For all outbound A.M. peak service combined, alightings would have totaled at most about 35 at Mansfield and 40 at Attleboro.

In the P.M. peak, Mansfield and Attleboro were also served by three inbound trains in Spring 2000. Train 818 originated at South Attleboro and Train 822 originated at Providence. When the April 2000 counts were done, Train 820 originated at South Attleboro. Starting in Summer 2000, Train 820 was extended to Providence, because it used the equipment from outbound P.M. peak Train 813 which was being extended. This initially resulted in Train 820 running 35 minutes later than before at stations previously served. The Train 820 schedule was changed again in December 2000 making the times 26 minutes later than they were in April 2000. These schedule changes may have altered ridership patterns from those discussed below.

The April 2000 counts included boardings at most stations for Trains 820 and 822 but not Train 818. At Attleboro there were 14 ons on Train 820 and seven on Train 822. At Mansfield there were 29 ons on Train 820 and nine on Train 822. Counts for Train 818 were done only at Back Bay and Station. With a distribution of boardings similar to that on Train 820, Train 818 would have had about 15 ons at Attleboro and 32 at Mansfield. This would have raised total P.M. peak boardings at these stations to 36 at Attleboro and 70 at Mansfield. The Attleboro total estimate is slightly lower than the outbound A.M. peak estimate above, but the Mansfield number is twice as large as the A.M. peak estimate. Non-commuting trips could account for the discrepancy at Mansfield, but even small errors in the relative numbers of riders allocated to Mansfield and Attleboro in the A.M. or P.M. estimates could also contribute to the imbalance.

The 1993 survey showed a total of 37 inbound P.M. peak work-to-home trips from Mansfield to the Boston stations, but only 14 of these had final destinations in Boston. Mansfield Station is in a town center, but there are no major individual employers within convenient walking distance of the station. None of the 37 work-to-home trips reported walk-in access, and 21 of the 37 originated at a then-new office park just over the town line in Foxborough. A private shuttle van ran to that location from the station. There is no public transportation alternative other than the train for traveling from Boston to Mansfield. A private carrier bus route from Boston to Providence includes a stop in Foxboro on some trips, but the only one that would be suitable for reverse commuters is an early-morning outbound trip.

The survey showed only 11 work-to-home trips boarding at Attleboro Station, including seven with final destinations in Boston. The station is in an old city center, with only a few large individual employers nearby. All of the seven Boston residents walked to the station from their work locations. There is no public transportation alternative other than the train for traveling from Boston to Attleboro.

Fairmount Line

On this line, Uphams Corner, Morton Street, and Fairmount are all served by the same three outbound A.M. peak trains (Trains 745, 749, and 751) in Spring 2000. The counts then included one to three observations of alightings from each of these trains at each of these stations.

At Uphams Corner, Train 745 had no alightings on the three days it was observed and Train 751 had no alightings on the one observation day. Train 749 had two offs on one day but none on another. At Morton Street, no offs were observed from Trains 745 or 751. Train 749 had one off on one day and none on another.

At Fairmount, Train 745 had one off on each observation day. Train 749 had three offs on one observation day and one on another. Train 751 had one off on the one observation day. In total, there were three to five offs from these three trains.

In the P.M. peak, Uphams Corner, Morton Street, and Fairmount were all served by the same four inbound trains (Trains 766, 768, 770, and 772). The Spring 2000 counts included at least one observation of boardings at each of these stations on Trains 768, 770, and 772. Train 766 was observed only at South Station.

At Uphams Corner, Train 768 had three ons on the one count day. Train 770 had no ons on any of three days. Train 772 had no ons on the one day observed. At Morton Street, Train 768 had no ons on the one count day. Train 770 had no ons on either of two count days. Train 772 had two ons on the one day observed. At Fairmount, Train 768 had three ons on the one count day. Train 770 had four ons on one day and one on another. Train 772 had two ons on the one day observed. In total, the three trains had six to nine ons at Fairmount.

Train 766 had no South Station alightings on the one observation day. All or most of the riders boarding at Uphams Corner, Morton Street, and Fairmount would have been going to South Station, so possibly excluding some interzone trips, Train 766 would have had no boardings at those stations. Before 2000 the last inbound P.M. peak counts on the Fairmount Line by CTPS were done in 1993. A train on about the same schedule as Train 766 had three alightings at South Station, but there were no survey responses from that train to indicate where passengers boarded.

Counts were not done in 2000 for Train 764, which stopped at Fairmount, Morton Street, and Uphams Corner between 3:03 and 3:11 P.M. This would have been too early for most trips home from work. The 1993 count for the train showed a total of 12 offs at South Station. Surveys on this train showed that there were at least two boardings at Fairmount and at least one each at Morton Street and Uphams Corner. The below-average response rate suggests that many of the riders not accounted for were school children, who would have been likely to be riding at that time of day, and who would most likely have boarded at Readville.

The combined A.M. and P.M. peak results from Uphams Corner, Morton Street, and Fairmount show that there is very little off-peak direction ridership to any of these stations. The day-to-day count variation indicates that much of what ridership there is consists of non-repetitive trips.

All three stations are within the city of Boston and are located in areas with a mixture of residential, commercial, and industrial development. Uphams Corner Station is directly

on MBTA bus Route 15 from the Orange Line and a short distance from Routes 16 and 17 from the Red Line. Morton Street Station is directly on Route 26 from the Red Line and Route 21 from the Red and Orange Lines. It is also a short distance from Routes 28, 29, and 31 from the Orange Line. Fairmount Station is directly on Route 24 from Mattapan and a short distance from Route 33 from Mattapan and Route 32 from the Orange Line. Under the present fare structure, the cost of a trip involving only the Fairmount line would be less than that of a combined bus and rapid transit trip to Uphams Corner or Morton Street, but the train fare would be higher to Readville. There are relatively few homes close enough to South Station to allow use of the Fairmount Line alone for reverse commuting.

Old Colony Lines

Quincy Center and Braintree are both served by some trains on each of the two Old Colony branches. During A.M. peak hours, three outbound trains stopped at each station in Spring 2000. The counts then did not include alightings there from all of these trains, but such counts were done in October 1999. The three trains stopping at Quincy Center (Trains 003, 005, and 061) had no alightings there in those counts. In March 2000, Train 003 still had no Quincy alightings, Train 005 had two, and Train 061 was not observed.

Of the three trains stopping at Braintree (Trains 003, 033, and 061) only Train 033 had any alightings there in October 1999, with three. In March 2000, the same train also had three Braintree alightings, but the other two were not observed.

In Spring 2000 South Station was the only stop before Quincy Center. The only train with alightings at Braintree did not stop at Quincy Center. Therefore, all passengers alighting at either station had to have boarded at South Station. The Red Line offers much more frequent service from South Station to both Quincy Center and Braintree, and the Red Line fares are lower. The advantages of the Old Colony lines are faster running times and more comfortable seating, but these advantages are apparently insufficient for most commuters. For comparison, Spring 1997 counts found 910 riders alighting from outbound Red Line trains at Quincy Center and 234 at Braintree in A.M. peak hours. These included riders boarding before and after South Station as well as there.

A new Old Colony stop adjoining the Red Line JFK/UMass station in Dorchester opened on April 30, 2001. The initial schedule, in effect at this writing, did not include any outbound A.M. peak or inbound P.M. peak trains stopping there, so any reverse-commuters from South Station would still have to use the Red Line.

Stations with Two Outbound A.M. Peak Trains

Thirty-eight stations in the commuter rail system each had two outbound A.M. peak trains in Spring 2000, making this the most common service level. Within this total were several subgroups of stations on the same lines and served by the same trains. In such

cases they are discussed together to minimize duplication of information. All stations on the Haverhill/Reading, Lowell, and Fairmount lines had either more or fewer than two outbound A.M. peak trains.

Newburyport/Rockport Line

The Newburyport/Rockport Line had a total of seven outbound A.M. peak trains, but they served various combinations of stations, so none was served by all seven. At Beverly Junction (north of Beverly Depot) where the line divides into two branches, two trains continued to Rockport and served all stations on the line except Prides Crossing. The later of the trains arrived at Rockport at 9:38, after the end of the A.M. peak as defined for this study. Two other trains ran to Newburyport. One of these stopped at all stations north of Beverly. The other omitted North Beverly and Hamilton/Wenham, but a second train for those two stations was provided by a Hamilton/Wenham short-turn trip. (The other two outbound A.M. peak trips terminated at Beverly Depot.)

The Spring 2000 counts did not include boardings and alightings at individual stations north of Beverly Depot. Upper bounds on reverse commuting to these stations from Boston can be determined from North Station boarding counts and alighting counts at some of the stations before Beverly Junction.

The two Rockport trains (Trains 103 and 109) had a total of 69 passengers departing North Station. Based on partial alighting counts and on alighting patterns from other trains, it would be expected that no more than half of these riders, or about 35, would have remained on board past Beverly Depot. This would have been an average of six riders for each station served, but some stations would have been more likely than others to attract reverse commuters.

Expanded results from the 1993 survey show three work-to-home trips to Boston from Gloucester, five from Manchester, and two from Montserrat, but none from Beverly Farms, West Gloucester, or Rockport during P.M. peak hours. No school-to-home trips were reported from any stations on this branch. Rockport and the three stations with reverse commuters are all in business districts, but Beverly Farms and West Gloucester are in low-density residential areas. The trains are the only public transportation link from Boston to any of these stations.

The two Newburyport trains (Trains 151 and 153) and the Hamilton/Wenham short turn (Train 191) had a combined total of 105 riders leaving North Station in Spring 2000. Based on partial alighting counts and on alighting patterns from other trains, it would be expected that no more than about 25 of these riders would have remained on board past Beverly Depot. This would be an average of five riders for each station served, but some stations would have been more likely than others to attract reverse commuters.

At the time of the 1993 survey, the branch that now runs to Newburyport terminated at Ipswich. The survey found two inbound P.M. peak work-to-home trips from Ipswich to North Station but none from Hamilton/Wenham or North Beverly. The Ipswich trips

did not have final destinations in Boston. All three stations are located in low-density business districts with no major employers nearby. (Hamilton / Wenham Station is on the border of those two towns, but in Hamilton.) North Beverly Station is also served by MBTA bus Route 451 from Salem, but most trips on that route do not have convenient Boston connections either from express buses or from trains that do not continue to North Beverly. There is no bus service to Hamilton, Wenham, or Ipswich.

Rowley Station is in a very sparsely developed area, about one half mile from the town center, which has no major employers. Newburyport Station is on the border of Newbury, beyond convenient walking distance from the Newburyport city center. There are some industries closer to the station, but the walking paths to them are not good. The 1990 Census found only seven work trips from Boston to Rowley, and 42 to Newburyport. There is no bus service to Rowley. Three private-carrier bus companies run service between Boston and Newburyport, but together they offered only one outbound A.M. peak trip and three inbound P.M. peak trips in 2000. These bus trips stopped only at a park-and-ride lot at a highway interchange well outside of downtown Newburyport.

Fitchburg Line

Stations on the Fitchburg Line served by exactly two outbound A.M. peak trains in 2000 were Belmont, Waverley, Kendal Green, Lincoln, West Concord, and South Acton. All six were served by Trains 453 and 455, which terminated at South Acton, and were the first two of the trains that stop at all stations that had three trains.

Belmont and Waverley

The Spring 2000 counts included North Station ons and ons and offs at Porter Square, Belmont, and Waverley for Trains 453 and 455, but did not include counts at any of the four two-train stations further out on the line. No attempt was made to determine passenger trip purposes. After leaving Porter Square, the two trains carried a total of 262 riders. This number was believed to be lower than usual because of Spring breaks at Brandeis University and at the Cambridge School of Weston near Kendal Green. Nine passengers alighted at Belmont and seven more at Waverley. Both stations are in commercial districts, so they could serve some reverse commuters, but there are no large employers nearby. Both stations are also within walking distance of schools.

The 1993 survey found no reverse commuters boarding at Belmont or Waverley to return home. Consistent with this, counts in 1994 found only two outbound A.M. peak offs at Belmont and one at Waverley. Belmont Center can also be reached from Boston using a combination of the Red Line and bus Route 74 or 75. Waverley can be reached using a combination of the Red Line and trackless trolley Route 73.

Other Stations

The Spring 2000 counts showed 70 passengers alighting from Trains 453 and 455 at Waltham. At Brandeis / Roberts 59 passengers got off the second train, and at least another 25 more would have been expected to alight from the first train, for which a

count was not done. Including boardings after Porter, the two trains would then have had a total of about 115 riders on board after Brandeis / Roberts, destined for one of the remaining stations with only two trains or for Concord. This would have been an average of 23 offs per station. The 1993 survey results indicate that about 45 students at the Concord Academy returned home to stations east of Brandeis / Roberts. With a similar number riding outbound in the A.M. peak in 2000, the number of other offs per station west of Brandeis / Roberts would have dropped to an average of 14.

A 1994 count found 33 outbound A.M. peak offs at Kendal Green (in Weston), consisting mostly of students for the nearby Cambridge School, but that school was reportedly on break during the 2000 counts. The 1993 survey did not find any inbound work-to-home trips from that station or from South Acton. From Lincoln, the survey found three work-to-home trips to North Station, with final destinations in Boston. The survey showed six work-to-home trips from West Concord Station to North Station, but only four had Boston destinations.

The Kendal Green, Lincoln, and South Acton stations are all outside of the centers of the towns they serve, and are not near any other large employers. A private shuttle bus now connects South Acton with the Clock Tower Place office park in Maynard, about two miles away. A January 2001 count found 34 riders alighting from outbound A.M. peak trains at South Acton, of which 19 transferred to the bus. (The sponsors of the bus believed that the majority of the transfer riders came for origins other than Boston.) This service is discussed in greater detail in chapter 6. The West Concord Station is in a small business district, but with few large employers within walking distance. At present there is very limited bus service from Boston to Weston, Lincoln, Concord, or Acton, and it is all scheduled for commuting to work in Boston.

Framingham/Worcester Line

At the time of the Spring 2000 counts, stations on the Framingham / Worcester Line served by exactly two outbound A.M. peak trains were Wellesley Square, Natick, West Natick, and Framingham. All four were served by Trains 505 and 507. Shortly after the counts, former Framingham Train 509 was replaced by Worcester Train 559, which arrived at Wellesley Square at 9:28. This is within the A.M. peak as defined for this study. Train 509 was due at Wellesley Square at 9:33, just after the end of the A.M. peak. Effective April 30, 2001 Framingham gained a third outbound A.M. peak trip, provided by new Worcester Train 503, due at Framingham at 7:25.

The Spring 2000 counts included ons and offs at all stations on Trains 505 and 507. These trains left Back Bay with a combined total of 175 riders. Both then ran non-stop to Wellesley Hills, where they dropped 22 riders, who could only have boarded at Boston, and picked up four. At Wellesley Square, they dropped 51 riders, all of whom probably came from Boston, because of the short distance from Wellesley Hills, and four more boarded. At Natick 31 riders alighted and five boarded. Based on interzone ridership patterns in the 1993 survey, at least 29 of the alighting riders boarded in Boston. At West Natick, 17 riders alighted but none boarded. Based on the 1993 survey results, at

least 15 of the alighting riders boarded in Boston. At Framingham, a total of 69 riders alighted. This most likely included the seven who boarded at Natick and the four who boarded at Wellesley, leaving at most 58 from Boston.

The 1993 survey showed a total of 29 inbound P.M. peak work-to-home trips from Wellesley Square to the Boston stations, all with final destinations in Boston. The same trains also had 14 school-to home trips from Wellesley to the Boston stations, also with final destinations in Boston. The 2000 counts imply a slight absolute increase in reverse commuting work or school trips between Boston and Wellesley compared with 1993. The addition of a third outbound A.M. peak train has probably had little impact on such ridership, because the train arrives at Wellesley too close to the end of the peak.

At this writing, the new outbound A.M. peak train at Framingham has not been running long enough to allow an evaluation of its impact on ridership. It is due in Framingham only 15 minutes before Train 505, but this difference might be enough to attract some new riders with strict workplace arrival time requirements not met by Train 505.

Needham Line

Stations on the Needham Line served by exactly two outbound A.M. peak trains in Spring 2000 were Forest Hills, Roslindale, Bellevue, and Highland. All four were served by Trains 605 and 607, which were the first two trains serving three-train stations. In the Spring 2000 counts, these two trains had a total of 58 riders as they left Back Bay. The counts did not include passenger activity at any of the two-train stations, except that ons and offs for Train 607 were counted at Forest Hills. Only one passenger alighted from Train 607 there. This was the same as the count from a train that ran on about the same schedule in 1994. The 1994 count also showed only one alighting there from Train 605. The two trains left Back Bay with a total of 69 riders then.

The earlier train was the only one stopping outbound at Roslindale, Bellevue, or Highland in the A.M. peak in 1994. The counts then showed one off at Roslindale and none at either of the other two. Alternate transportation to the vicinities of all of these stations is provided by a combination of the Orange Line and MBTA local buses. These offer greater frequency and lower fares but somewhat longer on-board times than the Needham Line. Given the competition, and the decrease between 1994 and 2000 in total outbound A.M. peak ridership on trains serving the two-train stations, there is no reason to assume that the number of offs there have increased much if at all in that time.

Franklin Line

The only stations on the Franklin Line served by exactly two outbound A.M. peak trains in Spring 2000 were Dedham Corporate Center and Walpole. The former is served only by Trains 795 and 707, and the latter only by Trains 793 and 795. All three trains picked up passengers at South Station but only Train 707 stopped at Back Bay. All served some stations in addition to Dedham Corporate Center and Walpole. In Spring 2000, passenger activity for Train 793 was counted only at South Station, where there were 24

ons. Possible alighting locations were Readville, Norwood Central, and Walpole. Based on alightings from Fairmount Line trains at Readville, most passengers on Train 793 would have been expected to ride further than that. An estimate of 10 offs each at Norwood Central and Walpole is reasonable.

Counts for Train 795 were done only at South Station, where 37 riders boarded, and at Dedham Corporate Center, where 12 of them alighted, leaving 25 Boston passengers for all remaining stations. This train also stopped at Norwood Central, Windsor Gardens and Walpole, then continued to Forge Park stopping at all stations. It was the only A.M. peak train going to stations beyond Walpole. Alightings after Dedham Corporate Center would have averaged about four per station, though some would have had more than others. Walpole probably had no more than 20 outbound A.M. peak offs from both trains combined. (The 1993 survey found only one work-to-home trip from Walpole Station to Boston.)

The Spring 2000 counts showed Train 707 leaving Back Bay with 44 riders. Seven of these were counted alighting at Dedham Corporate Center making the two-train total 19 outbound A.M. peak offs there. The 1993 survey found only six work-to-home trips from Dedham Corporate Center. A February 1994 count showed a total of eight passengers alighting at Dedham Corporate Center from the two outbound A.M. peak trains, and all but one left the station on foot. The survey results suggest that most of these were home-to-work trips. Because of the location of the station, most of the increase in outbound A.M. peak offs from 1994 to 2000 would also be expected to be in reverse commuting work trips.

Attleboro/Stoughton Line

The only stations on the Attleboro / Stoughton Line served by exactly two outbound A.M. peak trains in Spring 2000 were Sharon and South Attleboro, served by Trains 803 and 805. The counts then included boardings and alightings at all stations for Train 803, but counts for Train 805 were done only as far as Route 128 Station. Train 803 had 71 passengers on board after Ruggles Station and 44 after Route 128, included three who boarded there. At Sharon there were three offs, probably all from Boston. At South Attleboro there were eight offs, probably also from Boston.

Train 805 had 50 riders on board after Ruggles and 29 after Route 128 compared with 71 and 44 on Train 803. Train 805 terminated at South Attleboro, however, whereas Train 803 continued to Providence. At least eight and possibly more Boston riders on Train 803 rode to Providence, reducing the difference between the two trains at stations north of there. Train 805 stopped at Canton Junction, but Train 803 did not. Overall, the results suggest that Train 805 would have had no more Boston offs at Sharon and South Attleboro than the maximum of three and eight from Train 803.

Middleborough/Lakeville Line

All stations on the Middleborough / Lakeville Line south of Braintree had two outbound A.M. peak trains (Train 003 and 005) in Spring 2000. Counts then showed a combined total of 48 riders leaving Boston on these trains, with 46 remaining on board after Quincy Center. No counts were done at individual stations south of Quincy. The only detailed CTPS counts south of Braintree were done in October 1998. At that time the two trains had 37 Boston riders traveling beyond Quincy, or 20% fewer than in 2000. Alightings at individual stations ranged from one at Montello to 26 at Bridgewater, but the only other station with more than seven offs was Brockton with 14. A total of 11 riders boarded at stations south of Boston, and would have been included in the alighting counts. Inbound P.M. peak survey results from 1998 showed a total of 10 work-to-home trips from Bridgewater Station to South Station, equivalent to 38% of the A.M. peak outbound offs at Bridgewater, but only four had final destinations in Boston.

The main attraction for the outbound alightings at Bridgewater Station is the state college, which was on break when the March 2000 counts were done. The most recent CTPS counts prior to that were done in September 1999. They showed 69 riders going from South Station to points south of Braintree on Trains 003 and 005, or 86% more than on October 1998. Pro-rating these among all stations would result in 48 offs at Bridgewater. Allocating all of the increase there would make 58 offs. Of these, an estimated 18 to 22 would be work trips boarding at South Station.

The 14 offs at Brockton would increase to 26 with a pro-rated share of Boston boardings. The survey results showed only four work-to-home trips from Brockton to South Station, which would increase to eight with a pro-rated share of growth.

Plymouth/Kingston Line

On the Plymouth / Kingston Line, stations with two outbound A.M. peak trains in Spring 2000 were South Weymouth, Abington, Whitman, and Hanson. These were all served by Trains 033 and 061. Train 033 also served Halifax and Kingston. Train 061 also served Halifax and Plymouth, but arrived at both after the end of the A.M. peak. March 2000 counts showed 40 riders on board these trains leaving South Station, but three rode only as far as Braintree. The 1998 survey results showed no reverse commuting trips to schools on this line, so Spring breaks would not have affected the totals. The total was almost the same as in October 1998, when 38 riders boarded in Boston and all continued beyond Braintree. Among stations with two trains, Whitman then had the largest number of alightings, with seven, and South Weymouth was second, with six. Abington and Hanson had two each. Halifax had two offs from Train 033 and one from Train 061. Kingston had 10 offs from Train 033. Plymouth had 11 offs from Train 061. The 1998 survey results showed a total of 22 work-to-home trips to South Station from all stations on the Plymouth / Kingston Line after the A.M. peak. This suggests that about 60% of the outbound A.M. peak trips from South Station were home-to-work trips.

In the survey, South Weymouth had the largest number of work-to-home trips, with eight. Kingston and Hanson were tied at five each, and Plymouth accounted for the rest, with four. The low total number of P.M. peak inbound riders and low survey response rates put some uncertainty in these distributions, but it is clear that there are few reverse commuting work trips from Boston to any station on this line.

Stations with One Outbound A.M. Peak Train

Six of the 11 commuter rail lines had at least one station with only one outbound A.M. peak train in Spring 2000. These were the Newburyport/Rockport, Haverhill/Reading, Framingham/Worcester, Franklin, Attleboro/Stoughton, and Plymouth/Kingston lines. All stations on the other five lines had either more than one train or none.

Newburyport/Rockport Line

The only station on this line with exactly one outbound A.M. peak train was Rockport served by Train 103. (Train 109 arrived at Rockport at 9:38, shortly after the end of the A.M. peak as defined for this study.) An April 2000 count found 28 passengers boarding Train 103 at North Station. As the net result of ons and offs, there were 32 passengers on board after Swampscott, but at most 16 of them could have boarded in Boston. At least half of these would be expected to have alighted at Salem or Beverly Depot, leaving at most about eight Boston riders for the six stations on the Gloucester Branch. (Train 109, which stopped at all of the same stations as Train 103 except River Works, left Boston with 41 riders, or 46% more than Train 103, in an April 2000 count.) The 1993 survey did not find any inbound work-to-home trips from Rockport.

Haverhill/Reading Line

All stations north of Reading on this line were served by only one outbound A.M. peak train in Spring 2000. The outer five stations (Ballardvale, Andover, Lawrence, Bradford, and Haverhill) were all served by Train 205, which was routed via the inner end of the Lowell Line and also stopped at Mishawum and Wilmington. North Wilmington was served only by Train 209, which was due there at 9:30, and ran via Reading. Train 209 was also the only outbound A.M. peak train stopping at Greenwood Station in Wakefield. In a December 1997 count, this train had no offs at either Greenwood or North Wilmington. The Spring 2000 count showed the same total boardings at North Station and Malden as in 1997, but did not include alightings at other stations. It is reasonable to assume that there were still no offs at Greenwood or North Wilmington.

The Spring 2000 count for Train 205 was done only at North Station, where there were 89 ons. A December 2000 count found 23 offs from this train at Mishawum. These could only have boarded in Boston. If total Boston boardings were the same as in the Spring, this would have left 66 alightings at other stations including Wilmington. Estimating six offs at Wilmington would leave a total of 60 for stations on the Haverhill/Reading Line, or nearly three times the number observed on the same train in a December 1997 count. Pro-rating the 2000 total by the 1997 count would make

approximately four offs each at Ballardvale and Andover, 28 at Lawrence, 14 at Bradford and 10 at Haverhill.

The 1993 survey found five inbound work-to-home trips boarding at Haverhill, 17 at Lawrence, two at Bradford, and six at Andover, but none at Ballardvale or North Wilmington. All of these passengers rode to North Station, but not all of them had final destinations in Boston.

Framingham/Worcester Line

The only station on this line served by exactly one outbound A.M. peak train in Spring 2000 was Wellesley Farms. Framingham Train 509 was due at Wellesley Farms at 9:26 A.M. then. It was subsequently replaced by Worcester Train 559 due at Wellesley Farms at 9:21. Passenger activity for Train 509 was counted only at South Station and Back Bay. The train left Back Bay with 54 riders, or 56% of the number on Train 507, which stopped at all of the same stations except Wellesley Farms. Unlike the other two stations in Wellesley, Wellesley Farms is in a predominantly residential area. Based on the observed alightings from Train 507 at Wellesley Hills and Wellesley Square, Train 509 would not be expected to have had more than five alightings at Wellesley Farms. The 1993 survey did, however, show seven work-to-home trips from Wellesley Farms to Boston, apparently by domestic workers.

Franklin Line

Five stations on this line were served by only one outbound A.M. peak train in Spring 2000. Windsor Gardens, Norfolk, Franklin, and Forge Park were served only by Train 795, which also stopped at Dedham Corporate Center, Norwood Central, and Walpole, but was not the only train stopping at any of those. Endicott Station was served only by Train 707.

In Boston, Train 795 stopped only at South Station, and a Spring 2000 count showed 37 passengers boarding there. Twelve of these alighted at Dedham Corporate Center, leaving 25 for the remaining six stations. This was an average of four each, but individual counts were not done at those stations. Based on the results on Train 735, Norwood Central would be expected to have had more than four alightings, leaving a smaller average for the other stations. The 1993 survey found one work-to-home trip to Boston from Forge Park, five from Franklin, three from Norfolk, and two from Windsor Gardens.

Counts for Train 707 were done on two different days in Spring 2000. On one day there were three alightings at Endicott and on the other there were none. The 1993 survey found no reverse commuting trips to Endicott. Based on the observed variation in ridership and on the fact that the station is in a residential area, it can be concluded that reverse commuting activity there is still negligible.

Attleboro/Stoughton Line

The only station on this line with just one outbound A.M. peak train in Spring 2000 was Providence, served by Train 803. In March 2000, an on-board count of ons and offs at all stations was done for this train. Leaving Ruggles Station there were 71 riders on board, of which only 41 remained after Route 128. At Providence there were 33 alightings. Taking into account activity at intermediate stations, between eight and 20 of these riders came from Boston. The 1993 survey showed a total of 13 work-to-home trips from Providence to Boston on the one inbound P.M. peak trip, which is consistent with the range above. On the survey day, the train left Providence with 44 riders, but ons and offs were not counted at intermediate stations before Boston. In April 2000, a count was done at stations from Attleboro in on the one inbound P.M. peak trip then run from Providence. There were 55 riders on board before Attleboro. They could have boarded only at Providence or South Attleboro, so there was little or no change in Providence boardings from 1993.

A second inbound P.M. peak Providence train at a time more convenient for some commuters was added in the Summer of 2000. This may have resulted in increased use of the outbound A.M. peak train.

Plymouth/Kingston Line

The only station on this line served by only one outbound A.M. peak trip in Spring 2000 was Kingston. It was served by Train 033, which also stopped at all other stations on the line except Quincy Center. A March 2000 count showed 29 passengers boarding at South Station, with 26 remaining after Braintree, but counts were not done at individual stations beyond that. Control counts for the 1998 survey showed 20 South Station passengers remaining on board after Braintree. At Kingston 10 passengers alighted, and at least eight of them had to have boarded in Boston. The survey showed only five work-to-home trips from Kingston to Boston all day, which is consistent with this range. Allocating the entire increase in ridership on Train 033 between 1998 and 2000 to Kingston reverse commuting trips would raise the total to 11. Pro-rating the increase to all stations would raise it to only seven.

Stations with No Outbound A.M. Peak Trains

In Spring 2000, only 18 stations in the entire commuter rail system had no outbound A.M. peak service. Most of these were on the Fitchburg and Framingham / Worcester lines, but there were also a few on other lines. In some cases the lack of service was a result of operating constraints, but in others it was because of probable lack of demand.

Newburyport/Rockport Line

The only station on this line with no outbound A.M. peak service was Prides Crossing in Beverly. Trains 103 and 109 both passed through this station in the A.M. peak, and both stopped at the adjoining stations on either side, Montserrat and Beverly Farms. Prides

Crossing Station is in a low-density residential area, and has historically been one of the least-patronized stations on the line. November 1994 counts found only 24 riders boarding the three inbound A.M. peak trains there, compared with 66 at Beverly Farms.

At times in the past, Train 103 or Train 109 or both were scheduled to stop at Prides Crossing on request. This practice apparently ended in 1981, when both trains were temporarily replaced by buses because of track work. Lack of demand rather than any operating constraint appears to be the reason that service was not restored.

Fitchburg Line

Seven stations on this line had no outbound A.M. peak service in Spring 2000. Two of these, Hastings and Silver Hill, are between Boston and South Acton, and outbound Trains 453, 455, and 417 all passed through them in A.M. peak hours. These are the two least-patronized stations on the line in terms of peak-direction travel, and only local lobbying has prevented Silver Hill from being eliminated entirely as a stop. CTPS counts in November 1994 found a total of 13 boardings at Hastings on the four inbound A.M. peak trains stopping there, and eight at Silver Hill on the two trains stopping there.

Both stations are in lightly populated residential areas, with no possible sources of employment except as household help. Both stations are in Weston, at rail distances of 0.5 and 1.5 miles from Kendal Green Station. The 1994 counts found a total of 33 passengers alighting from the two outbound A.M. peak trains stopping there, but at least 23 of these were students who transferred to vans to go to the Cambridge School of Weston. Kendal Green is the nearest station to that school. The 1993 survey did not show any work-to-home trips boarding at Kendal Green. It is unlikely that there would be any reverse commuters to Hastings or Silver Hill even if service were available.

The furthest point from Boston on this line with outbound A.M. peak service in 2000 was South Acton. Trains 453 and 455 terminated there. Train 417 ran through to Fitchburg, but reached South Acton and all stations beyond after 9:30 (used as the limit of the outbound A.M. peak in this study). With present scheduled running times, if Train 453 were extended west, it could theoretically reach Fitchburg at 9:00. The furthest west that Train 455 could get by 9:30 would be Littleton / Route 495, one stop past South Acton. As discussed further in chapter 4, such extensions would also prevent the equipment sets from these trains from being used on the next inbound trips to which they are currently assigned. Assuming that new trips from Fitchburg replaced those trains, scheduling constraints caused by single track would require later arrivals west of South Acton than indicated above.

Framingham/Worcester Line

Five stations on this line had no outbound A.M. peak service in Spring 2000. This included all three stations in Newton (Newtonville, West Newton, and Auburndale). Outbound Trains 505, 507, and 559 (subsequently renumbered 509) passed through

these stations during the A.M. peak but could not stop there because of the track and platform configuration, discussed further in chapter 4.

In January 2001, selected commuter trains began stopping at Yawkey Station in Boston, which had formerly been used only as a special stop for ballgames at nearby Fenway Park. The number of trains stopping there was increased in April 2001, but has not yet included any outbound A.M. peak trains. As at the Newton stations, the track and platform configuration at Yawkey do not allow all trains to stop there. (At this writing, two inbound P.M. peak trains stop at Yawkey.)

At the time of the Spring 2000 counts, no outbound A.M. trains ran further than Framingham. In May 2000, one of the A.M. Framingham trains was replaced by a Worcester train leaving South Station at 9:00 A.M., stopping at Grafton at 9:59 and due at Worcester at 10:14. This would have been too late for most work travel. In February 2001 a new Worcester train leaving South Station at 4:55 A.M. and due in Worcester at 6:13 was started. This train did not stop at Grafton and was too early for most work trips. It carried few riders. Effective April 30, 2001, the 4:55 A.M. Worcester train was discontinued. It was replaced by a new train leaving South Station at 6:50 A.M. and due at Grafton at 7:55 and at Worcester at 8:05. At this writing, it is too soon to evaluate ridership on this train. A tentative future schedule for service on this line calls for outbound trains arriving in Worcester at 6:34, 8:09 and 8:54 A.M., as discussed further in chapter 4. At present, there is insufficient rolling stock available to run all of these trains.

In addition to commuter rail service in 2000, there was an Amtrak intercity train leaving Boston at 7:55 A.M. and arriving in Worcester at 8:54, with only one intermediate stop at Framingham. The schedule of this train has changed twice since then. At this writing, it leaves South Station at 7:30 A.M. An inbound Amtrak train for Boston was scheduled to leave Worcester at 5:02 P.M., but it originated in Chicago and was often very late. Furthermore, the fares on these trains were too high to attract commuters.

Worcester is about the same distance from Boston as Providence, and also has similar levels of employment opportunities. Because of the lower speed limits and greater number of intermediate stations on the Framingham / Worcester Line, travel times to Worcester are longer than those to Providence, however. The tentative schedule for A.M. peak service calls for times ranging from 74 to 79 minutes between South Station and Worcester. The present scheduled time from South Station to Providence on the one outbound A.M. peak train is 60 minutes. As discussed above, recent passenger counts show that at most about 20 riders a day commute from Boston to Providence and the actual number is closer to 15. As discussed in chapter 2, the greatest potential demand for reverse commuting service west of Framingham would be at Westborough, but in absolute terms it would be only slightly greater there than at Worcester.

Franklin Line

The only stations on the Franklin Line with no outbound A.M. peak service in Spring 2000 were Islington, Norwood Depot, and Plimptonville. Trains 793 and 795 passed through all three stations during the A.M. peak without stopping. Train 735 also passed through Islington and Norwood Depot but not Plimptonville. Islington station is in the town of Westwood, and is close to several low-rise warehouses and industrial plants where there may be employment opportunities. The available walking paths to most of these from the station are not very direct, however.

In Spring 2000, five inbound A.M. peak trains stopped at Islington, so it would have been possible to commute to work locations near the station from points further out on the line. October 1994 counts found no passengers alighting at Islington from any A.M. peak trains. The 1993 survey did show two A.M. peak work-to-home trips to Islington, both boarding at Norfolk Station. Both walked to their final destinations, one in 10 minutes and the other in 15. The passenger with the longer walk did not have a car available. Overall, these results suggest that Islington Station would attract few reverse commuters if outbound A.M. peak trains stopped there.

Norwood Depot is only 0.5 miles from Norwood Central, where three outbound A.M. peak trains stopped in Spring 2000. Both stations are within the Norwood business district, and both are within walking distance of some large industrial plants. Four inbound A.M. peak trains stopped at Norwood Depot. All of these and two others also stopped at Norwood Central. The one that would be expected to attract the greatest number of interzone commuters was Train 710 from Forge Park, which was due at Norwood Depot at 8:15 A.M. A count there in 1994, when Train 710 was due at 8:19, found only one passenger alighting from it. The 1993 survey did not find any inbound home-to-work trips to Norwood Depot, but found two to Norwood Central.

The Spring 2000 counts included passenger activity at Norwood Central from only the last of the three A.M. peak outbound trains (Train 735). It had 18 offs there. Partial counts on Trains 793 and 795 suggest that they each would have had about 10 offs at Norwood Central, raising the overall total to 38. These were not necessarily all home-to-work trips. The 1993 survey showed only four work-to-home inbound trips from Norwood Central.

Effective April 30, 2001, outbound Train 735 began stopping at Norwood Depot at 8:30 A.M. before terminating at Norwood Central at 8:33. At this writing, it is too early to evaluate ridership at Norwood Depot.

Plimptonville Station is in Walpole, 1.4 miles from Walpole Station. It is also 1.1 miles from Windsor Gardens Station in Norwood. Plimptonville is the least-used station on the Franklin Line. Only one train a day in each direction stops there. A September 2000 Ticket Audit Report showed only three riders boarding at Plimptonville. The station is in a mostly residential area, and is about one mile from the nearest large employers.

The latter are served directly by MBTA bus Route 34E from Forest Hills. In conclusion, reverse commuting service to Plimptonville would be unlikely to attract any riders.

Attleboro/Stoughton Line

The only station on this line with no outbound A.M. peak service in Spring 2000 was Hyde Park. Six outbound Attleboro/Stoughton trains and two Franklin Line trains passed through Hyde Park without stopping in the A.M. peak. Fairmount Station on the Fairmount line is less than one half mile on foot from Hyde Park Station. Three outbound trains (Trains 745, 749, and 751) stopped at Fairmount in the A.M. peak. Spring 2000 counts found one Fairmount alighting each from Trains 745 and 751. Train 749 had one off on one day and three on another. The Hyde Park Station area can also be reached from downtown Boston via MBTA bus Routes 32 or 50 from the Orange Line at Forest Hills. All of these findings suggest that reverse commuting service to Hyde Park Station would attract few new riders.

Plymouth/Kingston Line

The only station on this line with no outbound A.M. peak service in Spring 2000 was Plymouth. The outer end of the line is divided into two branches, with one terminating at Kingston and the other at Plymouth. Otherwise, trains from either terminal serve the same stations. The first outbound train of the day (Train 033) went to Kingston, arriving there at 8:10 A.M. The equipment from this train departed at 8:33 as Train 040, due in Boston at 9:28. As discussed further in chapter 4, it would be feasible to change the outer terminal of this train from Kingston to Plymouth if the demand justified it. The Fall 1998 counts found 10 riders alighting from Train 033 at Kingston. CTPS has not done more recent counts there. Spring 2000 counts at South Station and Braintree showed a net increase of only six riders going from Boston to all points South of Braintree on Train 033.

There has been no outbound A.M. peak service to Plymouth since the line reopened in 1997, so it is unclear whether Train 033 would serve more riders by going there instead of to Kingston. The survey results showed only five work-to-home trips from Kingston Station to South Station all day, and three of these originated in Plymouth. There were four work-to-home trips from Plymouth Station to South Station, suggesting that the number would have been larger than that at Kingston if more peak-period service had been offered. The demand estimates in chapter 2 show no appreciable difference between the two stations. Whichever station had outbound A.M. peak service would also have to have inbound P.M. peak service to allow passengers to return home.

On April 30, 2001, a platform for Old Colony trains opened at the JFK/UMass Red Line station. Selected trains on the Plymouth/Kingston and Middleborough/Lakeville lines began stopping there, but this did not include any outbound A.M. peak or inbound P.M. peak trains on either line. Scheduling constraints imposed by the many single-track segments in the Old Colony lines may prevent future implementation of reverse commuting service at JFK/UMass.

4. TECHNICAL FEASIBILITY AND COST OF INCREASED REVERSE COMMUTING SERVICE

Introduction

Task 6 of the Reverse Commuting Study Work Program called for an analysis of the cost and technical requirements of increasing commuter rail service in order to provide a minimum of three outbound A.M. peak and three inbound P.M. peak trains at every suburban employment area, while preserving current peak direction schedules or adjusting the schedule of any train by at most 10 minutes. At present, and for many years past, peak-period commuter rail schedules have been dictated primarily by considerations of serving travel to and from work locations in Boston. Most trains that run outbound in the A.M. peak either do so to bring equipment from layover facilities in Boston to outlying stations before the first inbound trips of the day, or are returning to outer starting points after completing previous inbound trips. Most inbound P.M. peak trains are scheduled either to bring equipment to Boston in time for the first outbound trips or to return it to Boston after previous outbound trips.

This chapter examines schedules at all stations that currently have two or fewer outbound A.M. or inbound P.M. peak trains, to determine what changes would be necessary to bring service up to the three-train minimum standards, and whether doing so would improve travel options for reverse commuters. For purposes of analysis, the three-train standard is assumed to require that at least three outbound trains arrive at a station between 6:30 and 9:30 A.M., and that at least three inbound trains depart from that station between 3:30 and 6:30 P.M. It should be noted that even where this basic standard is met, trains would not necessarily arrive or depart at times most needed when work shifts and travel times to and from stations are taken into consideration. Since the same causes of low service levels usually apply to several stations on a given line, the analysis has been done on a line-by-line basis. Spring 2000 service levels are shown in Table 3-1. Possible improvements and costs of these improvements are summarized in Table 4-1 and in the first section following it. Subsequent sections provide a more detailed analysis of each line.

Implementation of all identified changes on all lines would increase annual operating costs by about \$13,260,000. These changes would also require acquisition of five new train sets at an initial cost of about \$58,600,000. With the level of ridership estimated in chapter 2, annual revenue to the commuter rail system would increase by at most \$4,000,000, equal to 30% of the added operating cost, so the annual subsidy level would have to increase by \$9,260,000. Furthermore, part of the \$4,000,000 revenue gain would be offset by losses in revenue on MBTA express and feeder bus routes because of diversions to the new commuter rail service.

Disregarding diversions from other transit services, the annual operating subsidy per new weekday commuter rail rider would be about \$6,200. This does not include operating costs of feeder connections that would be essential to the success of the train service. The capital cost per new passenger for new train sets alone would be about

\$39,300. Costs of fixed facility improvements such as additional passing sidings or second track would add to this. If ridership fell significantly below the optimistic projections above, the average costs would be much higher.

Explanation of Capital and Operating Cost and Revenue Assumptions

All of the operating costs in this chapter were calculated by applying a cost-per-mile factor obtained from the MBTA to the change in annual train-miles that would occur on each route. Annual train-miles were calculated by multiplying daily train-miles by 254, the number of days a year that weekday commuter rail service is currently provided. It was assumed that no additional reverse commuting service would be run on Saturdays, Sundays, or major holidays.

As of Fall 2000, the most recent calculation of the average cost per train-mile for MBTA commuter rail service was \$46.50, based on an average train length of six cars. With present equipment assignments and assumed rotation to cover expanded service, the extra trips run for reverse commuting would all use trains of 5, 6, or 7 cars. Using adjustment factors developed from prior studies to account for variation of operating cost with train length, the per-mile cost used in the calculations for the reverse commuting study was reduced to \$44.46 for a five-car train but increased to \$48.59 for a seven-car train. (For the system as a whole, the difference in estimated cost between using the six-car rate for all trains and varying cost by train length was less than 2%.)

The only capital costs included in the calculations were for additional rolling stock that would be needed to run reverse commuting trains that could not be provided with equipment from the present fleet that would otherwise be idle. Based on the most recent available costs for MBTA rolling stock acquisition, the assumed unit costs were \$2,000,000 each for diesel-electric locomotives and \$1,800,000 each for bi-level coaches. These could be subject to some variation, depending on the number of units included in one order.

The calculations did not include any expansion of layover and servicing facilities that would be required to accommodate the additional trainsets when not in use. These requirements are discussed in greater detail in the Operating Constraints section below and in appendix A. Layover capacity in Boston is already a problem, because increases in Amtrak intercity service are reducing the amount of space allocated for commuter trains at the Southampton Street yards. It is impossible to put a cost on added expansion needed for reverse commuting service without knowing what the overall strategy for Boston layover facilities is going to be.

Revenue at the ridership levels estimated in chapter 2 was calculated by multiplying the number of weekday riders to each city and town shown in Table 2-2 by the average commuter rail fare from Boston at present fare levels and with the average mix of fare payment options found in past fare-mix studies. Weekday one-way revenue was doubled and multiplied by 254 to represent annual revenue. This total was then increased by 9.6% to represent revenue from additional induced demand.

Table 4-1
Estimated Operating and Capital Cost of Changes Needed to Provide Minimum Standard
Reverse Commuting Service on all MBTA Commuter Rail Lines

Line	Change	Increase in Annual Operating Cost	Added Rolling Stock Capital Cost
Rockport	Add AM peak round trip North Sta - Rockport	\$800,000	
Rockport	Replace one PM peak North Sta - Beverly round trip with Rockport round trip	\$385,000	
Newburyport	Replace two AM peak North Sta - Beverly round trips with one Newburyport round trip	(\$5,000)	
Newburyport	Replace one PM peak North Sta - Beverly round trip with Newburyport round trip	\$405,000	\$11,000,000
Haverhill	Add one AM peak outbound North Sta - Haverhill trip	\$390,000	
Haverhill	Replace one AM peak North Sta - Reading round trip with Haverhill round trip	\$485,000	
Haverhill	Replace one PM peak North Sta - Reading round trip with Haverhill round trip	\$485,000	\$11,000,000
Fitchburg	Add AM peak round trip North Sta - Fitchburg; Replace two South Acton round trips with Fitchburg trips	\$2,240,000	\$11,000,000
Fitchburg	Add PM peak round trip North Sta - Fitchburg; Replace two South Acton round trips and one outbound South Acton with Fitchburg trips	\$2,200,000	(applies with any or all of a.m. or p.m. changes)
Worcester	Add one AM peak outbound Worcester Train	\$525,000	
Needham	Add one AM peak outbound Needham Heights Train	\$170,000	
Franklin	Replace one outbound A.M. non-revenue Forge Park trip with two A.M. peak revenue trips	\$375,000	
Franklin	Add AM peak round trip South Sta - Forge Park	\$715,000	\$12,800,000
Franklin	Add PM peak inbound trip Forge Park - South Sta	\$440,000	
Attleboro	Add one AM peak outbound trip South Sta - Providence	\$515,000	\$12,800,000
Attleboro	Add one PM peak inbound trip Providence - South Sta	\$515,000	(applies to one or both)
Stoughton	Replace one PM peak South Sta - Canton Jct round trip with Stoughton round trip	\$95,000	
Middleboro	Add AM peak round trip South Sta - Middleborough / Lakeville	\$845,000	
Kingston	Add AM peak round trip South Sta - Kingston or Plymouth	\$840,000	
Kingston	Add one PM round trip Kingston - South Sta	\$840,000	
	GRAND TOTAL	\$13,260,000	\$58,600,000

Note: Costs above do not include modifications to fixed facilities such as tracks, signals, stations or yards.

Revenue from reverse commuters already using commuter rail was calculated by a similar method and was subtracted from the total to find new commuter rail revenue. Changes in revenue on other MBTA services including rapid transit and local and express buses was not calculated. Such diversions would be expected to account for over one third of the total reverse commuting riders on the improved commuter rail system. Because of the many possible combinations of alternatives and fares, estimates of revenue diversions from present services would require a complex analysis that would still not yield very precise results. The revenue-to-cost ratio of the commuter rail improvements would be unfavorable even with optimistic demand assumptions, and taking into account revenue diversions from other services could only make the ratio lower. (Calculations of the factors for induced demand and for diversions from other services are discussed further in appendix B.)

Summary of Findings

Newburyport/Rockport Line

At present, all stations on this line from Beverly Depot to Chelsea, inclusive, have between three and six outbound A.M. peak trains and between three and six inbound P.M. peak trains. This segment of the route is served by trains on both the Rockport Line and the Newburyport Line, which divide just north of Beverly Depot. Service includes trains going to and from the outer ends of both lines and also Hamilton / Wenham and Beverly Depot short turns. In contrast, none of the stations north of Beverly Depot have more than two reverse commuting trips in either peak, and some have one or none in either or both peaks.

In the A.M. peak it would be feasible to increase outbound service to stations on the Rockport Line from two trains to three by running a new train with equipment that would otherwise be idle in Boston, but it would probably carry fewer than 20 riders from Boston to points north of Beverly Depot. This train and the two present ones serving the line (Trains 103 and 109) could all stop at Prides Crossing, which now has no reverse commuting service, but there is little or no demand there. The added operating cost of a new train would be about \$800,000 a year.

Increasing outbound A.M. peak service to three trains at all stations north of Beverly Depot to Newburyport could be accomplished by extending Beverly Depot short-turn Train 61, but this would require dropping inbound Train 62 and redistributing the riders to the preceding and following trains. This change would probably attract fewer than 20 new riders going to points beyond Beverly Depot, and would inconvenience the 300 users of Train 62 and the riders of the trains that they would have to shift to. The new Newburyport train could also replace inbound Train 64, allowing outbound Train 63 to be dropped. These changes would reduce operating expenses by a net of about \$5,000 a year but would inconvenience more riders than they would benefit.

Inbound P.M. peak service on the Rockport Line could be improved by having the equipment from Train 129, due in Rockport at 6:05, make a new inbound trip at 6:15

instead of remaining in Rockport overnight. Between Beverly Depot and Boston, this train would replace short-turn Train 72. The equipment from outbound Train 69, which now turns to Train 72 at Beverly Depot would be run through to Rockport, so each terminal would end up with the same number of equipment sets as at present. The added operating cost of these changes would be about \$385,000 a year. Because of the low potential reverse commuting ridership on the Rockport Line, the main benefits to these changes would be increased outbound P.M. peak service and increased early evening service for trips to Boston for purposes other than returning from work.

Adding a third inbound P.M. peak trip at stations from North Beverly to Newburyport could be accomplished by extension of a Beverly Depot short turn, but this would require acquisition of an additional train set to maintain schedules of other trains that now use the same equipment. Operating cost would increase by about \$405,000 a year, and the capital cost of the new train set would be about \$11,000,000. The reverse commuting potential at the stations north of Beverly could not justify these costs.

Haverhill/Reading Line

At present, all stations on this line from Malden Center to Reading have three or four outbound A.M. peak trains each except for Greenwood which has only one. Stations north of Reading have only one outbound A.M. peak train each, and at North Wilmington the only arrival is at 9:30. In the P.M. peak, all stations between Reading and Malden have three or four inbound trains, except Greenwood and Wyoming Hill which have only two each. All stations north of Reading have two inbound P.M. peak trains except North Wilmington, which has none.

Adding stops at Greenwood by outbound A.M. peak trains that do not currently stop there would interfere with these trains making their next scheduled inbound departures. The one outbound A.M. peak trip that now stops at Greenwood and later morning trains all have few or no outbound alightings there. Service to this location is also provided by buses from the Orange Line. Therefore, there is no need to provide additional outbound A.M. peak trains to Greenwood.

In the P.M. peak inbound service at Greenwood and Wyoming Hill could be increased from two trips each to three by adding stops on train that now run through them without stopping. Counts on trains that do stop at these stations indicate that few or no riders would take advantage of the added stops, however.

A second outbound A.M. peak trip for stations north of Reading (excluding North Wilmington) could be provided by basing the equipment for the fifth inbound Haverhill train (Train 212) in Boston instead of at the Bradford yard, and running it outbound at 5:55 A.M., but such a trip would be expected to attract fewer than 20 new riders. Another possibility for adding a second (or third) outbound A.M. peak trip would be to use the equipment from inbound Train 208 on a new outbound trip leaving Boston at about 8:25. This train would also be expected to attract fewer than 20 new riders. A new inbound train leaving Haverhill around 9:40 would have to be run to

return the equipment to Boston in time for its next assignment. This trip would be expected to serve no more than about 60 new riders. Inbound, it would replace Reading short-turn Train 266. This would also allow outbound Train 261, which carried nine riders in the Spring 2000 count, to be dropped. The added operating cost of basing the equipment for Train 212 in Boston instead of at Bradford would be about \$390,000 per year. The net added operating cost of running a new Haverhill round trip and dropping a Reading round trip would be about \$485,000 a year.

Adding a third inbound P.M. peak trip serving stations north of Reading would require assigning an additional train set to the line to maintain existing trips that carry more riders than the potential ridership on the new inbound Haverhill train. The latter volume would not be expected to exceed 40 new riders. The net operating cost increase of the new Haverhill train, if run as a replacement for a Reading short-turn, would be about \$485,000 per year. The capital cost of an additional train set would be about \$11,000,000.

Lowell Line

At present, all stations on the Lowell Line are served by three or four outbound trains in the A.M. peak and by three to five inbound trains in the P.M. peak. Therefore, no changes in service would be required to provide the minimum of three reverse commuting trains in each peak called for in the work program.

Fitchburg Line

The Fitchburg Line is currently the longest MBTA commuter rail route, at 49.6 miles, and the levels of reverse commuting service vary among stations. Of the 17 stations on the line, none have more than three outbound A.M. peak or three inbound P.M. peak trains. Only four stations, Porter Square, Waltham, Brandeis/Roberts, and Concord have three outbound A.M. peak trains, and each of these also has three inbound P.M. peak trains. Six stations, Belmont, Waverley, Kendal Green, Lincoln, West Concord, and South Acton, have two outbound A.M. peak trains each. Of these stations, all have three inbound P.M. peak trains, except Waverley which has only two. None of the other seven stations on the line (Hastings, Silver Hill, Littleton/Rte 495, Ayer, Shirley, Leominster, and Fitchburg) has any outbound A.M. peak or inbound P.M. service except that Littleton/Rte 495 has one inbound train at the start of the P.M. peak.

At stations between Boston and South Acton, adding stops by trains that currently pass through non-stop would attract few or no new riders in either peak, and would in some cases delay departures of subsequent trains that use the same equipment sets. Inbound A.M. peak trains from Fitchburg all leave there too early to allow equipment for them to be first run out from Boston at times that would be useful for reverse commuting. Assignment of one additional train set to the line would allow schedules to be modified to include two outbound A.M. peak trains to all stations west of South Acton and a third to Littleton/Route 495. The capital cost of the added train set would be about \$11,000,000. The added operating cost of the expanded service would be about

\$2,240,000 a year. Present single track between South Acton and Ayer constrains times at which trains can be run on that segment. This would result in less than optimal departure times in one or both directions under the expanded schedule.

It would not be worthwhile to run A.M. peak reverse commuting service without P.M. peak service. Assignment of one additional train set to the Fitchburg Line would also make it possible to run three inbound P.M. peak trains from stations west of South Acton. The added cost of doing this would be at least \$2,200,000

Because the outer stations currently have no reverse commuting service in either peak, there are no figures from which to extrapolate or interpolate ridership on new trains. Historically, none of the cities and towns west of South Acton have employed large numbers of Boston residents commuting by any means of transportation. New commuter rail service could not be expected to capture much of this limited market nor to increase it significantly. Based on this and on experience on other lines, each reverse commuting train would be expected to carry fewer than 20 riders going to or from stations west of South Acton.

Framingham/Worcester Line

Present (Spring 2001) levels of reverse commuting service on this line vary among stations. No stations have more than three inbound A.M. peak or outbound P.M. peak trains and some stations have no reverse commuting service. The only stations with three outbound A.M. peak trains are Wellesley Hills, Wellesley Square, and Framingham. Natick and West Natick have two trains each, Wellesley Farms, Grafton, and Worcester have one each, and Newtonville, West Newton, and Auburndale have none. In the P.M. peak, only Framingham has four inbound trains. West Natick, Natick, Wellesley Hills, and Wellesley Square have three trains each, and Wellesley Farms has two. Newtonville, West Newton, Auburndale, Grafton, and Worcester each have one inbound P.M. peak train.

Provision of more reverse commuting service at Newtonville, West Newton, or Auburndale would require installation of platforms on the track that now has none. The number of new reverse commuters attracted would be insufficient alone to justify the expense of doing this, which would be likely to exceed \$2,000,000 per station. If such platforms were built for other reasons, reverse commuting service to these stations could be provided by stopping selected trains that now pass through them.

Addition of a third outbound A.M. peak train serving stations between Framingham and Worcester should be considered if the two trains already planned are found to attract significant numbers of reverse commuters. Based on available information, such a train would carry a total of about 30 to 40 riders to stations west of Framingham and about 50 to Natick, West Natick, and Framingham combined. This train could be added by basing the equipment for the fourth inbound Worcester train in Boston instead of Worcester and running an outbound train leaving Boston at about 6:15. The added cost of such a train would be about \$525,000 per year. Operation of this train might conflict

with through freight service schedules, however. No increase in inbound P.M. peak service would be needed to meet the three-train minimum at the stations likely to generate the most ridership.

Needham Line

At present in the A.M. peak, West Roxbury Station and the four stations in Needham (Hersey, Needham Junction, Needham Center, and Needham Heights), all have three outbound trains. The other four stations (Forest Hills, Roslindale, Bellevue, and Highland) are each served by two of the three trains. In the P.M. peak all stations have three inbound trains except for Highland, Bellevue, and Roslindale which have only two each.

Bringing all Needham Line stations up to the minimum reverse commuting standard of three outbound A.M. peak trips and three inbound P.M. peak trips would require only that stops be added to trains that now pass through some stations without stopping. Present spacing of outbound A.M. peak trains limits flexibility of travel times for reverse commuters, however. Another train could be added by changing the overnight layover point of one train set from Needham Heights to Boston, but the most desirable schedule for the new train may be incompatible with plans for expansion of intercity service using shared tracks between Boston and Forest Hills. Based on available ridership counts, adding stops to existing trains would attract little or no new ridership. Ridership on a new outbound A.M. peak trip earlier than the present first one would also be low, probably not exceeding 25 riders. The added operating cost of a new train would be about \$170,000 a year.

Franklin Line

At present, the only station on the Franklin Line with three outbound A.M. peak trains and three inbound P.M. peak trains is Norwood Central. Dedham Corporate Center and Walpole each have two reverse commuting trains in each peak. Norfolk, Franklin, and Forge Park each have one outbound A.M. peak and two inbound P.M. peak trips. Endicott and Windsor Gardens have one reverse commuting train in each peak. Norwood Depot has one outbound A.M. peak train, but no inbound P.M. peak trains. Islington and Plimptonville have no reverse commuting trains in either peak period. The relatively low level of reverse commuting service on this line is largely a consequence of long sections of single track, and the high level of peak-direction service needed because of heavy ridership.

In the A.M. peak it would be technically feasible to increase outbound service at stations north of Norwood Central by having Trains 735 and 795 make more stops, but Train 735 would need to leave Boston earlier than at present. This would inconvenience riders who now use this train to ride only from South Station to Back Bay.

To increase service at stations south of Norwood Central, it would be necessary to run more Forge Park trains. The equipment for inbound Trains 708 and 710, which is now

run out of Boston in non-revenue service before the start of the A.M. peak, could theoretically be run out in revenue service during the A.M. peak. This would require some delays to inbound departures because of limited passing locations on single track, and arrivals at most stations would be too early for most work shifts. Running the equipment for Trains 708 and 710 out of Boston in separate revenue service trains instead of in a non-revenue double set would increase operating costs by about \$375,000 a year.

Operation of a new outbound train at a time more useful for commuters would require assignment of an additional train set if no existing service were to be dropped. The capital cost for a new six-car train set for an additional Franklin train would be about \$12,800,000. The annual operating cost of one additional A.M. peak round trip would be about \$715,000.

Inbound P.M. peak service could be brought to a minimum of two trains at all stations by having Trains 720 and 798 stop at stations that they now pass. A third inbound train for stations from Walpole south could be provided by having the equipment from Train 797 make an inbound trip from Forge Park at 6:00 P.M. instead of going immediately to the Franklin layover facility. The net increase in operating cost resulting from this change would be about \$440,000 a year.

Based on available information, the potential reverse commuting ridership at Franklin Line stations that now have fewer than three outbound A.M. peak or three inbound P.M. peak trains is low. Additional stops at stations north of Norwood Central would be expected to attract no more than five riders per train, and probably fewer, at any station. Additional service south of Norwood Central would be expected to attract fewer than 20 new riders per train at all stations combined. Therefore, the additional operating and capital cost needed to implement such service would be very high relative to the benefits.

Attleboro/Stoughton Line

The Attleboro / Stoughton Line has the highest overall level of reverse commuting service of any South Side Line, but frequency varies widely among stations. As of Spring 2001, Route 128 and Canton Junction each have five outbound A.M. peak trains. Route 128 also has five inbound P.M. peak trains and Canton Junction has four. Mansfield now has four outbound A.M. peak trains and three inbound P.M. peak trains. Attleboro has three reverse commuting trains in each peak. Stoughton, Canton Center, and Ruggles also have three outbound A.M. peak trains but only one, one, and none inbound in the P.M. peak. Sharon and South Attleboro each have two outbound A.M. peak and three inbound P.M. peak trains. Providence has only one outbound A.M. peak and two inbound P.M. peak trains. Hyde Park has no outbound A.M. peak trains but four inbound P.M. peak trains.

Outbound A.M. peak service at Hyde Park might be raised to a minimum of three trips by adding stops for some trains that now pass through without stopping, but the

potential demand for reverse commuting service to that station appears to be insufficient to justify the disruption in schedules of other trains that would result. The number of new riders would probably not exceed the maximum of three per train observed at the nearby Fairmount Station.

Sharon could be provided with a third trip by having Train 833 (old Train 831) stop there. A Spring 2000 count for one of the two trains now stopping there showed only three alightings. The other train was not observed at Sharon, but had fewer total riders on board leaving Boston.

A second outbound A.M. peak train to Providence could be provided at no cost by allowing Train 801 to carry passengers that far. A slightly later Boston departure would also allow this to be a third South Attleboro train. A third Providence train also functioning as a third or fourth South Attleboro train would require use of a new train set. The outbound trip would end too late to allow the equipment to be used to expand inbound A.M. peak service. The one outbound A.M. peak train to Providence had 33 offs there in Spring 2000, but only about 13 of these riders apparently came from Boston. The same train had eight offs at South Attleboro but the other train stopping there was not observed that far. New trains would be likely to attract similar totals at these stations. The capital cost of equipment needed for the new train would be about \$12,800,000. The added operating cost of a one-way trip would be about \$515,000 a year.

Present track and platform layout would not allow inbound P.M. peak service to be provided at Ruggles, but there is little or no demand for such service. Raising inbound P.M. peak service at Canton Center to three trains could be accomplished by adding a stop by Train 920, and advancing the departure time of Train 922 from Stoughton. The latter change would also give Stoughton a second inbound P.M. peak train. A third train for Stoughton could be provided by extending outbound Train 879 and inbound Train 880 to there from Canton Junction. This would increase annual operating costs by about \$95,000. In the Spring 2000 counts, only the second of the three outbound A.M. peak Stoughton trains was observed over its entire route. It had only one off at Canton Center and two at Stoughton. All three Stoughton trains had similar total loads leaving Boston. Limited inbound P.M. peak service may have been partly responsible for the low outbound A.M. peak ridership.

The possibility of running a third inbound P.M. peak train from Providence is limited by the schedules of Amtrak intercity trains on the same line. Based on recent outbound A.M. peak ridership, such a train would attract at most about 15 work-to-home trips to Boston. The added cost of such a train would be \$515,000 a year if the equipment remained in Boston afterwards, or \$1,030,000 if it had to be returned to Providence.

Fairmount Line

At present in the A.M. peak Uphams Corner, Morton Street, and Fairmount all have three outbound trains. Readville is served by four trains routed via the Fairmount Line

and a fifth routed via Back Bay. In the P.M. peak the three inner stations are served by four trains each and Readville is served by five. Therefore, no changes are needed to meet the minimum reverse commuting service standard of three outbound A.M. peak and three inbound P.M. peak trains at each station.

Middleborough/Lakeville Line

At present, the only stations on the Middleborough /Lakeville Line with three outbound A.M. peak trains are Quincy and Braintree, and that includes service by Plymouth / Kingston Line trains. All of the other stations have two trains each. In the P.M. peak, Bridgewater, Campello, Brockton, Montello, and Braintree have three inbound trains each. Middleborough /Lakeville, Holbrook /Randolph, and Quincy Center have two trains each.

It would be technically feasible to run a third outbound A.M. train on the Middleborough /Lakeville Line using equipment that would otherwise be sitting idle in Boston. Because of the need to coordinate the schedule with that of inbound service, this train would be much slower than the present two outbound A.M. peak trains on the line. It could be expected to carry around 45 passengers at best, and some of these would be diverted from other trains. The added operating cost of one A.M. peak round trip would be about \$845,000 a year.

Of the stations with only two inbound P.M. peak trains, Middleborough /Lakeville has a third train at 3:36 and Holbrook /Randolph has a third train at 6:32. These are close enough to the P.M. peak span that operation of a third train is not needed. Quincy Center has adequate service provided by the Red Line.

Plymouth/Kingston Line

At present (Spring 2001), the only stations on the Plymouth /Kingston Line with three outbound A.M. peak trains are Quincy and Braintree, and that includes service by Middleborough /Lakeville Line trains. All other stations have two trains each, except for Kingston and Halifax which have only one each, and Plymouth, which has none. In the P.M. peak, only Braintree has four inbound trains. Only Quincy Center has three, and all are Middleborough /Lakeville Line trains. The other stations have two trains each except for Hanson, Whitman, and Plymouth which have one each.

It would be technically feasible to operate one more outbound A.M. peak and one more inbound P.M. peak train on the Plymouth /Kingston Line using equipment that would otherwise be idle. In the A.M. peak most stations would then have three reverse commuting trains. Halifax would have two, with a third arriving just after the end of the A.M. peak. Depending on which terminal the train was run to, either Kingston and Plymouth would each have one train or Kingston would have two and Plymouth none.

The added inbound P.M. peak train along with additional stops by Train 048 would result in every station having three reverse commuting trains. Based on available

information, new ridership generated by the new trains would be small, not exceeding about 30 riders in either direction. Because of the need to reposition equipment for other trips, a new outbound A.M. peak train would also require a new midday inbound train, and a new inbound P.M. peak train would require a new outbound evening train. New morning and evening round trips would each increase annual operating cost by about \$840,000.

Detailed Analysis - Newburyport/Rockport Line

Rockport Line - A.M. Peak Service

On the Rockport Line, Montserrat, Beverly Farms, Manchester, West Gloucester, and Gloucester each have two outbound A.M. peak trains. The later one would be only marginally useful to reverse commuters, as it has arrival times ranging from 9:06 to 9:30 A.M. Rockport has only one outbound train arriving before 9:30, but a second train is due at 9:38. No outbound A.M. peak trains stop at Prides Crossing but two pass through it.

This line currently has three inbound A.M. peak trains, leaving Rockport between 6:10 and 7:25 A.M., and one pre-peak train leaving at 5:08. All four of these use equipment that is kept overnight at a layover facility at Rockport Station. If the equipment were kept instead in Boston and run out before the inbound trips, the first two trains would arrive at all stations before 6:00 A.M. The third would arrive before 6:30 at all stations except Gloucester and Rockport, where it would have to arrive no later than 6:31 and 6:38 to maintain inbound service. These times would also be of very limited usefulness. (Because of mandatory brake inspection and testing, a minimum of ten minutes is normally scheduled in the terminal for any train set when reversing directions.)

Equipment for the last inbound A.M. peak train, departing at 7:25, would need to arrive at Rockport by 7:15 and would reach Montserrat, the first station north of Beverly Depot, at about 6:43. With limited stops before that, the train would still need to leave North Station at about 6:10 A.M. At present the only departure earlier than that on any North Side line is a 5:45 trip to Lowell, which was found to have only 17 passengers boarding there in a Spring 2000 count.

At present, the equipment from every inbound train arriving at North Station prior to 7:54 A.M. is scheduled to depart on an outbound train on the same line or another by 8:20. The first two trains with long scheduled layovers in Boston are due at 7:54 and 7:55 and could theoretically be available for an outbound trip at 8:04 or 8:05. There is already a Newburyport train scheduled to leave at 8:05. To avoid a conflict with it, the departure of a new train with the equipment from the 7:54 or 7:55 arrival would have to be delayed until at least 8:10. Arrival times would range from about 8:46 at Montserrat to 9:18 at Rockport. Ridership would be expected to fall somewhere between that of the present preceding and following Rockport trains (Trains 103 and 109) ignoring diversions from those trains to the new one. Spring 2000 counts showed only 28 riders

leaving Boston on Train 103, and at most 16 of them rode further than Swampscott. Train 109 left Boston with 41 riders, and at most 20 of them rode further than Lynn.

The 1990 Census Journey-To-Work tabulations found that Manchester and Gloucester attracted only 34 and 174 reverse commuters from Boston by all means of travel, and that Rockport attracted none. With proportional shares of growth in employment since 1990, trips from Boston to Manchester and Gloucester would be expected to have grown by fewer than 10 each by 1999. All of the trips in 1990 were from outlying Boston neighborhoods, from which commuter rail would be expected to capture only small shares of travel. This suggests that a new outbound A.M. peak Rockport train would be expected to attract no more than about 10 new reverse commuting trips.

The equipment from the train arriving in Boston at 7:54 (Haverhill Train 208) is currently scheduled next for an outbound departure at 11:20. The equipment from the train arriving at 7:55 (Rockport Train 108) is scheduled next for an outbound departure at 12:10. If the equipment from one of these was used on a new outbound A.M. peak Rockport train, it would need to be returned to Boston by either 11:10 or 12:00. At present inbound Rockport Train 116 is due in Boston at 11:07 using the equipment from the outbound 8:30 train. The next Rockport train (Train 120) is due at 1:07. In between these, Newburyport Train 168 is due at 12:07. A new inbound Rockport train would have to run between Trains 116 and 168, with a Boston arrival around 11:37. This would limit the possible available equipment for the new round trip to that from Rockport Train 108. Because of the short spacing between trains, the new morning inbound return trip would be expected to attract fewer than 50 new riders.

The annual operating cost of a new round trip would be around \$800,000. Therefore, although it would be feasible to run a third outbound A.M. peak trip on the Rockport Line with available equipment, probable demand could not justify it.

From an operations standpoint there is no reason that either Train 103 or Train 109 could not stop at Prides Crossing, but there would be little benefit in doing this. The station is in a predominantly residential area with no major employers nearby. It is about one mile by road from Beverly Farms, where both outbound A.M. peak trains stop, so any passenger requiring transportation to a final destination could be met almost as conveniently at either station.

Rockport Line - P.M. Peak Service

The number of inbound P.M. peak trains at all stations on the Rockport Line is the same as the number of outbound A.M. peak trains, except that Rockport has two inbound trains instead of one. The two trains are Train 126, leaving Rockport at 3:40, and Train 130, leaving there at 5:22. Departures from other stations before Beverly Depot range up to 21 minutes later. These trains use equipment that arrives in outbound trains 12 to 16 minutes before the inbound departures, and there are no intermediate arrivals. Changing the departure time of either of these trains would not result in any net change in frequency, and could interfere with subsequent outbound assignments. Adding

another inbound trip between Train 126 and Train 130 would require adding another outbound trip leaving Boston at around 3:15. There is already a Newburyport train at that time and a Beverly Depot short-turn (Train 65) at 3:30. The latter train could theoretically be extended to Rockport, but the equipment would no longer be able to cover the outbound 5:10 departure to Newburyport as it now does.

After Train 130 at 5:22, the next inbound departure from Rockport is Train 94 at 6:45. This train runs in only as far as Salem, to turn and pick up transfer passengers from an outbound Newburyport train. At present, Train 129 is scheduled to arrive at Rockport at 6:05, and the equipment remains there until the next morning. This equipment could theoretically be used to add a new inbound departure at around 6:15, but after Beverly Depot this train would follow only about five minutes after the schedule of short-turn Train 72, which leaves there at 6:45. If the new train replaced Train 72, the equipment that now turns to Train 72 from Train 69 could continue through to Rockport, adding more outbound P.M. peak service and ending with the same amount of equipment in Boston and Rockport as at present. The annual operating cost increase resulting from these changes would be about \$385,000. Given the low potential demand for reverse commuting service on the Rockport Line, the main benefits to these changes would be the added outbound service, and filling a gap between the inbound 5:22 and 7:40 trains from Rockport for passengers going to Boston for reasons other than reverse commuting.

Newburyport Line - A.M. Peak Service

At present, two outbound A.M. peak trains run to Newburyport and one to Hamilton / Wenham only. The first Newburyport train (Train 151) runs non-stop between Boston and Ipswich, so North Beverly and Hamilton / Wenham are served only by the short turn and the second Newburyport train. Adding stops at these stations by Train 151 would lengthen its running time to Newburyport by four minutes, and would interfere with its scheduled meet with inbound Train 158 at the passing siding south of Ipswich Station. The Boston departure of this train could not be made earlier to compensate, because it uses the equipment from the first inbound Rockport train. Added arrival times at North Beverly and Hamilton / Wenham would occur at a few minutes after 7:00 and would be of use to relatively few reverse commuters.

The Newburyport Line currently has five inbound A.M. peak trains, leaving Newburyport between 5:27 and 7:55 A.M. The first four of these use equipment that is kept overnight at a layover facility near Newburyport Station. The fifth uses equipment from the first outbound train, which leaves Boston at 6:30. If the equipment for the four earlier trains were kept instead in Boston and run out before the inbound trips, the first two trains would have to arrive at all stations before 6:00 A.M., and the third would have to arrive before 6:20 to maintain inbound service. The fourth would need to arrive by 6:50. All of these times would be of very limited usefulness, and considerations of meets with inbound trains at passing sidings north of Beverly Depot could require even earlier times.

At present there is a long gap from 7:29 to 9:09 between outbound arrivals at Newburyport. As discussed above, the first equipment set to arrive in Boston on any line without a subsequent assignment is due at 7:54, and would be available for an outbound departure no sooner than 8:04. The train due at Newburyport at 9:09 already leaves at 8:05, so equipment available at 8:04 would be of no help in filling the gap.

If outbound Beverly Depot short-turn Train 61 leaving Boston at 7:15 were extended to Newburyport, it would arrive there at about 8:20. This would, however, leave no equipment for inbound Beverly Depot Train 62, which carries about 300 riders a day. These would have to be redistributed on the preceding and following trains, which would overload them unless cars were added. A new inbound Newburyport trip would also need to be added to return the equipment to Boston for its next assignment. Such a trip could replace inbound Beverly Depot short-turn train 64, due in Boston at 9:43. That train uses the equipment from outbound Train 63, which leaves Boston at 8:20, and had 24 riders in a Spring 2000 count. Train 63 could be discontinued if Trains 61 and 64 were extended to Newburyport.

The operating cost savings from discontinuing Trains 62 and 63 would exceed the added cost of extending trains 61 and 64 from Beverly Depot to Newburyport by about \$5,000 a year. The number of reverse commuters gained by running an extra Newburyport train would, however, be much smaller than the number of present riders inconvenienced by dropping Trains 62 and 63. A Spring 2000 count found only seven riders boarding the first outbound Newburyport train in Boston to go to Ipswich, Rowley, or Newburyport. The Hamilton / Wenham short turn left Boston with 52 riders, but no more than 10 to 15 of them rode beyond Beverly Depot. The second Newburyport train had 44 boardings at North Station, but no more than about 20 rode even beyond Lynn.

The 1990 Census Journey-To-Work tabulations did not find any reverse commuting trips from Boston to Hamilton. Ipswich, Rowley, and Newburyport attracted only 57, 7, and 42 reverse commuters from Boston by all means of travel. With proportional shares of growth in employment since 1990, trips from Boston to each of these towns would be expected to have grown by fewer than 12 each by 1999. A new outbound Newburyport train would be expected to attract fewer than 10 new reverse commuters going beyond Beverly Depot.

Newburyport Line - P.M. Peak Service

In the P.M. peak, stations from North Beverly to Newburyport inclusive each have two inbound trains departing between 3:30 and 6:30. The first outbound train that is scheduled to remain at Newburyport overnight rather than turning to an inbound trip is due at Newburyport at 6:15. At the earliest, a new inbound trip using this equipment would be able to leave Newburyport at 6:25 and it would reach all other stations after 6:30. In order to run a new inbound P.M. peak trains serving most of the stations, it would be necessary to add an outbound train. With the spacing of the present two inbound trains, the most useful time for another Newburyport departure would be

around 5:00. This would require an arrival no later than 4:50, and a Boston departure around 3:45, but to avoid a conflict with the schedule of inbound Train 178 north of Beverly Depot, an even earlier departure would be needed.

The new train could be run as an extension of Beverly Depot short-turn Train 65 leaving Boston at 3:30. It would follow only 15 minutes after Newburyport Train 175, which would limit potential new ridership. The equipment from Train 65 turns to Train 66, which carried only 16 riders in a Spring 2000 count. That train could be dropped. The equipment from Train 66 turns to outbound Newburyport Train 181, leaving at 5:10, but the new Newburyport train would be back in Boston at around 6:00 at the earliest. No other equipment would be available to cover Train 181, so the new train would require acquisition of another equipment set. The net operating cost increase of replacing trains 65 and 66 with a new Newburyport train would be about \$405,000 a year. The capital cost of the additional train set would be about \$11,000,000.

Given the low reverse commuting potential at stations north of Beverly Depot, adding either a third outbound A.M. peak train or a third inbound P.M. peak train on the Newburyport Line could not be justified.

Detailed Analysis - Haverhill/Reading Line

A.M. Peak Service - Reading and South

At present all stations on this line from Malden Center to Reading have three or four outbound A.M. peak trains each except for Greenwood which has only one. Stations north of Reading have only one outbound A.M. peak train each, and at North Wilmington the only arrival is at 9:30.

The lower service level at Greenwood is a result of having two Reading short-turn trains pass through Greenwood without stopping. Both trains have only the minimum allowances of ten minutes to change direction at Reading, so adding outbound stops at Greenwood would delay their inbound departures. North Station departures of both trains could be made slightly earlier to compensate for this. Greenwood is lightly patronized at all times. A December 1997 count found no alightings from the one A.M. peak train that stopped there or from the two following midday trains. MBTA bus Routes 136 and 137 provide connecting service almost directly to Greenwood Station from Malden and Oak Grove on the Orange Line, with much more frequent departures than added commuter rail stops would supply. Therefore, it is unnecessary to have any more outbound A.M. peak trains stop at Greenwood.

One of the Reading trains that skips Greenwood also skips Wyoming Hill, but the 1997 counts found no passengers alighting there from any of the three trains that did stop. Wyoming Hill is also served directly by MBTA bus Route 132 from Malden and Oak Grove. Routes 131 and 136/137 also have stops nearby. Therefore, there is no need to have another outbound A.M. peak train stop at Wyoming Hill.

A.M. Peak Service - North of Reading

The outer end of the Haverhill/Reading Line (that is, the segment north of Reading) currently has six inbound A.M. peak trains, leaving Haverhill between 5:31 and 8:43. (The last of these is due in Boston at 9:45, making it the latest arrival classified as peak service on any line.) The equipment for the first inbound train is kept overnight in Boston. It departs directly from the yards at around 4:00 A.M. as a non-revenue trip. There would be little or no demand for a revenue-service trip at that time, and no connecting services to North Station are in operation that early. Equipment for the second through fifth inbound trains is kept overnight at a layover facility near Bradford Station, and starts the day with short non-revenue trips from there to Haverhill. If equipment for these trains were kept instead in Boston, it would have to arrive in Haverhill at times ranging from about 5:55 to 7:15 A.M., with departure times from Boston between about 4:55 and 6:15. Spring 2000 counts on all MBTA commuter rail lines showed no more than 20 riders on any train leaving Boston before 6:30 A.M., so at most it might be worth considering running the equipment for the fifth inbound train (Train 212) out from Boston.

The Haverhill/Reading Line has single track between Reading Station and a point 0.4 mile south of Lawrence Station. This necessitates running the one outbound A.M. peak trip via the Lowell Line and the Wildcat Branch between Boston and Wilmington Junction to avoid scheduling conflicts with inbound trains. An additional outbound train would also have to be routed via the Wildcat Branch. A departure at 6:15 would be incompatible with present inbound schedules. The closest feasible time would be around 5:55.

At present the first outbound train running through to Haverhill leaves Boston at 7:19 A.M. A Spring 2000 count showed 89 passengers leaving Boston on that train. About 60 were going to stations on the Haverhill/Reading Line itself and the remainder to Mishawum or Wilmington on the Lowell Line. This trip has been operating since July 1997, when it replaced a departure at 6:55 A.M. That train had 37 Boston boardings in a December 1996 count, but only 21 of these had destinations on the Haverhill/Reading Line and 18 were going to Mishawum or Wilmington. A 5:55 departure would be expected to have even lower ridership than this.

The added operating cost of basing the equipment for Train 212 in Boston instead of at Bradford would be about \$390,000 per year if it were returned to Boston at the end of each day in a double set with an existing train. Adding a new inbound trip to reposition the equipment would double the extra cost.

The earliest inbound train on any line from which the equipment does not have an outbound assignment shortly after arriving at North Station is Haverhill Train 208, due at 7:54. This equipment could theoretically be used for a new outbound trip as early as 8:04, but to avoid conflicts with inbound Haverhill trains the earliest feasible departure time would be about 8:25. This train would have to be routed via Wilmington and

would arrive at Haverhill at about 9:28. This would be 30 minutes earlier than Train 209. In a Spring 2000 count, that train had only 20 riders boarding in Boston.

In order to have the equipment set available in Boston for its next current outbound assignment (the 11:20 train to Fitchburg), an inbound train leaving Haverhill at about 9:40 would also have to be added. If routed via Reading, it would follow only about 20 minutes after the present schedule of short-turn Train 266, which is due in Boston at 10:26. In a December 1997 count, that train had only 36 riders boarding at all stations between Reading and Boston. The outbound train from which the equipment for Train 266 turned (Train 261) carried only nine riders in Spring 2000 counts. Trains 261 and 266 could both be dropped, with the new Haverhill train replacing the inbound service. The next later Haverhill train (Train 218 due in Boston at 11:28) had 58 boardings north of Reading in 1997. A similar number could be expected on the new train, but some would be diversions from other trips. The net annual operating cost increase of adding a Haverhill round trip and dropping a Reading round trip would be about \$485,000.

The 1990 Census found only 30 reverse commuters from Boston to Haverhill, 139 to Lawrence, and 287 to Andover via all means of transportation. With proportional shares of changes in employment since 1990, trips from Boston to Haverhill and Lawrence would have changed insignificantly by 1999. Trips to Andover would have increased to about 365. The 1993 commuter rail survey showed only five work-to-home trips to Boston from Haverhill, 13 from Lawrence, and six from Andover. Two new outbound A.M. peak Haverhill trains would now be expected to attract a combined total of no more than about 50 new reverse commuters to destinations north of Reading.

P.M. Peak Service - Reading and South

In the P.M. peak, all stations between Reading and Malden have three or four inbound trains, except Greenwood and Wyoming Hill which have only two each. Reading short-turn trains 280 and 282 pass through both stations without stopping. Adding stops at these stations would lengthen the running times for these trains by three or four minutes each. This would still allow enough time for the train sets to turn to their following outbound assignments at Boston and would not interfere with schedules of outbound trains on the single-track section of the line south of Wyoming Hill. Nevertheless, there would be little benefit from adding these stops. December 1997 counts showed that no passengers boarded any of the six inbound trains that stopped at Greenwood between 3:00 and 11:00 P.M. A total of five riders boarded these same trains at Wyoming Hill, but only two did so in the P.M. peak.

P.M. Peak Service - North of Reading

All stations north of Reading have two inbound P.M. peak trains except North Wilmington, which has none. The trains serving the other stations are routed via the Wildcat Branch and the Lowell Line, so they do not even pass through North Wilmington Station. Wilmington Station on the Lowell Line is about 1.7 miles by road from North Wilmington, and is within walking distance of more potential employment

locations. Passengers who would need connecting transportation from North Wilmington could be provided with a connection from Wilmington instead. The reason for routing the inbound trains via the Lowell Line is to avoid scheduling conflicts with outbound trains on single track north of Reading. It would not be feasible to run them via Reading without installing additional second track or passing sidings.

The two inbound P.M. peak trips from Haverhill leave there at 4:30 and 5:55, using equipment that arrives in trains from Boston at 4:03 and 5:30. There are no outbound arrivals between these two. The next later train arrives at 6:20, and the equipment then goes to the Bradford layover facility for the night. The track layout at Haverhill requires that trains continue about one half mile beyond the station to cross between the outbound and inbound tracks. If the train arriving at 6:20 were to return to Boston instead of Bradford, it would not be able to leave Haverhill inbound until at least 6:35, which is after the end of the P.M. peak as defined for purposes of analysis.

In order to run another inbound train between 4:30 and 6:00, there would have to be an additional outbound train arriving between 4:03 and 5:30. If the Reading short-turn train leaving Boston at 3:50 (Train 275) were extended to Haverhill, it would arrive there at about 4:55, and could return at the earliest at about 5:10, arriving in Boston at about 6:15. Ridership to Boston on the inbound train would be expected to be somewhere between the 26 observed on the 4:30 departure and the 39 observed on the 5:55 departure in the Spring 2000 counts.

The equipment from Reading Train 275 now turns back to become inbound Train 280, due in Boston at 4:55. That train typically carries no more than 25 passengers, or slightly fewer than the number likely to use a new inbound Haverhill train. After arriving in Boston, however, the equipment from Train 280 is used on outbound Haverhill Train 231, departing at 5:15. There is no other equipment set available in Boston at that time to cover that trip. In the Spring 2000 counts it was the most heavily used trip on the route, with a peak load of 682 riders. Retention of this trip along with a new Haverhill round trip would require acquisition of an additional train set for the line. The net operating cost increase would be about \$485,000 per year. The capital cost of a five-car train set would be about \$11,000,000.

In summary, there is little or no potential demand for increased reverse commuting service at stations south of Reading that currently have fewer than three off-direction trains in either peak. North of Reading demand for additional service is also relatively small. The cost of providing such service would be very high, as it would require additional rolling stock and possibly installation of more double track.

Detailed Analysis - Fitchburg Line

South Acton and East - A.M. Peak Service

At present, in the A.M. peak two outbound trains leave Boston for South Acton and one leaves for Fitchburg. The two South Acton trains arrive there at 8:20 and 9:15. The

Fitchburg train arrives at South Acton at 9:34, just after the end of the A.M. peak as defined in this study. At any of the stations from Belmont to West Concord that currently have fewer than three outbound A.M. peak trains, it would be possible to increase service to that level by adding stops to trains that now pass through, but doing so would lengthen running times to subsequent stations. The two South Acton trains bypass only Silver Hill and Hastings. Stopping there would add about three minutes to arrival times at South Acton. The first train has enough slack in the schedule to accommodate this, but the second train has only the minimum 10-minute allowance between outbound arrival and inbound departure. Hastings and Silver Hill are both in lightly developed areas with no major employment sources nearby. They are only 0.6 and 1.5 miles from Kendal Green, where both trains stop. Therefore, there would be little benefit in having either of the two trains stop at Hastings or Silver Hill.

The outbound A.M. peak train to Fitchburg (Train 417) stops only at Porter Square, Waltham, Brandeis/Roberts, and Concord before reaching South Acton. Adding stops at all seven of the stations it omits would add about 19 minutes to the running time to South Acton and points further west. Adding stops to five of the omitted stations but not Hastings or Silver Hill would still add about 16 minutes. This train is due in Fitchburg at 10:15, and the equipment is then used on inbound Train 418 departing at 10:27. This is only two minutes longer than the standard 10-minute turnback allowance even if there are no delays. Therefore, lengthening the running time for Train 417 would require a later departure for Train 418.

For reasons discussed above, there is no need for Train 417 to stop at Hastings or Silver Hill. Belmont is also served by MBTA bus Route 74/78 and Waverley is also served by trackless trolley Route 73. Both of these routes connect with the Red Line at Harvard Station and offer more frequent, though slower, service from Boston than the Fitchburg Line. Spring 2000 counts on the two outbound A.M. peak South Acton trains show four alightings from the first and five from the second at Belmont. These trains had only three and four alightings at Waverley. Trip purposes were not determined. If Fitchburg Train 417 stopped at these stations it would probably have no more than five passengers alighting at either one.

Alighting counts were not done at Kendal Green, Lincoln, or West Concord in Spring 2000. An October 1994 count, when schedules were the same as at present, found 29 passengers alighting from the first train and four from the second at Kendal Green. Almost all of them were students at a nearby private school who transferred to a school bus there. If Train 417 also stopped at Kendal Green it would get there at 9:22 at the earliest. This would be too late for the students at the school. There is little employment within convenient walking distance of the station. Jobs along Route 128 that would require connecting transportation from Kendal Green could be reached more quickly by a connection from Waltham Station, where all three trains already stop. Therefore, there would be little benefit to having Train 417 stop at Kendal Green.

The 1990 Census showed a total of 81 Boston residents working in Lincoln. Since then, total employment in the town has decreased slightly. The greatest concentration of

employment is in the area around Hanscom Field, which is not close to Lincoln Station. The 1993 rail survey showed three work-to-home trips from Lincoln to Boston. If Train 417 were to stop at West Concord with no other intermediate stops added, it would get there at 9:31. This is just past the end of the A.M. peak as defined in this study.

South Acton and East - P.M. Peak Service

In the P.M. peak, the only stations east of South Acton that currently have fewer than three inbound P.M. peak trains are Silver Hill and Hastings, which have none, and Waverley which has two. Train 424 from Fitchburg and Trains 466 and 468 from South Acton all pass through Silver Hill and Hastings without stopping. Train 424 also skips Waverley. The rationale for skipping Silver Hill and Hastings is similar to that for omitting these stations on outbound A.M. peak trips. Spring 2000 counts on Trains 466 and 468 found only one passenger boarding each of them at Waverley. Train 424 could not be expected to do much better than that if it stopped there.

West of South Acton - A.M. Peak Service

At present, the segment of the Fitchburg Line west of South Acton has four inbound A.M. peak trains, departing Fitchburg at 5:45, 6:20, 6:55, and 7:20. The equipment for all of these trains is kept overnight at a layover facility about two miles east of Fitchburg Station and is run to Fitchburg in non-revenue trains before the start of service. If these train sets were kept in Boston instead, they would need to arrive at Fitchburg at the latest at times ranging from 5:35 to 7:10 A.M. Even with limited stops, they would need to leave Boston at times ranging from 4:15 to 5:50. Based on observations of the earliest trains on other lines, few riders would use a train leaving Boston even as late as 5:50.

At present, the earliest scheduled departure from North Station on any line is a Lowell train at 5:45 A.M. A Spring 2000 count found only 17 passengers boarding that train in Boston. On the South Side, well-established early departures include a 4:00 A.M. train to Forge Park, a 5:20 A.M. to Framingham, 5:15 and 5:35 trains to Stoughton and a 5:30 train to South Attleboro. All of these are run mostly to position equipment for inbound trips because of lack of layover facilities at the outer terminals. The only one of these trains for which a passenger count was done in Spring 2000 was the then 5:40 Stoughton train, which had 11 passengers as it left Back Bay. Conductor's headcount reports for the others indicate that total boardings at all stations seldom exceed 10 to 15 a day for each of these trains. (In addition to these trains, a Canton Junction train leaving Boston at 5:05 A.M. began operating on April 30, 2001, but no ridership figures for it are available yet. On the same date, a 4:55 A.M. Worcester train that had begun running on February 5 of that year was discontinued. It was reported to have carried almost no riders.)

The results above imply that there is little demand for trains leaving Boston before 6:00 A.M., but the average travel times on the routes listed are shorter than those from Boston to points west of South Acton on the Fitchburg Line. Therefore, compared with passengers on the other routes, those with work locations on the outer half of the

Fitchburg Line would need to leave Boston earlier to arrive at their destinations at any given time.

The first outbound short-turn Fitchburg Line train (Train 453) terminates at South Acton at 8:20 A.M. If this train were extended to Fitchburg making all intermediate stops and with the same running times as other off-peak trains, it would arrive at Fitchburg at about 9:11. This would be too late to return in inbound A.M. peak service. The equipment from Train 453 now turns to inbound Train 454 leaving South Acton at 8:41. A Spring 2000 count found a peak load of 156 riders on that train. This was the lowest ridership of any of the A.M. peak trains on the line, but was still much greater than the number of new riders that would be likely to use an extension of Train 453 to Fitchburg. Dropping Train 454 would force its passengers to use either 412, leaving 43 minutes earlier, or Train 456, leaving 44 minutes later.

If Train 454 were replaced by a new train from Fitchburg, an additional train set would have to be provided to run it. Scheduling of trains beyond South Acton is constrained by a single-track segment that extends from just east of South Acton Station to about 2.2 miles east of Ayer Station. It would not be possible to maintain the present schedules of both Train 453 and Train 454 between South Acton and Boston if both were extended to Fitchburg. If the schedule of Train 454 were maintained, the departure of Train 453 from South Acton would either have to be delayed by about 22 minutes or made about 10 minutes earlier. The latter choice is not feasible, because Train 453 uses the equipment from inbound Train 404, which is due in Boston only 13 minutes before the present departure time of train 453. There are no other available train sets in Boston at the right time to be substituted.

Delaying the Boston departure of Train 453 by 22 minutes would inconvenience those of its current riders who could no longer arrive at their destinations as early as they needed to. Maintaining the Boston departure time but waiting at South Acton for 22 minutes before proceeding would result in excessively long travel times to points beyond, and arrival times at many stations would be too late for most work trips.

If the present schedule of Train 453 were maintained with no delay before proceeding to Fitchburg, the extended Train 454 would have to leave South Acton either 22 minutes earlier or 10 minutes later than the present time. The earlier departure would put it only 20 minutes behind the time of Train 412, giving passengers less choice in travel time. A 10-minute delay would make arrival times too late for some riders. The best choice would probably be a compromise of a later departure for Train 453 and an earlier departure for Train 454.

The second outbound short-turn train (Train 455) terminates at South Acton at 9:15 A.M. If this train were extended to Fitchburg making all intermediate stops and with the same running times as other off-peak trains, it would arrive at Fitchburg at about 9:56. The furthest station from Boston it would reach before 9:30 would be Littleton / Rte 495 at 9:23, but it could reach Ayer at 9:31. Such an extension would be of limited usefulness for work trips. The equipment from Train 455 now turns to provide inbound

Train 456, leaving South Acton at 9:25. Unless this train were dropped, it would need to be replaced some other way. If the replacement was a new train originating at Fitchburg, it would have to leave there at 8:47 to maintain the present schedule, but no equipment would be available in Fitchburg at that time. As discussed above, an extended Train 453 would reach Fitchburg at about 9:11 at the earliest, but would probably be even later in order to coordinate with inbound service. Another 10 minutes would have to be allowed between outbound arrival and inbound departure, so if using this equipment, Train 456 would have to run at least 34 minutes later than its present schedule east of South Acton. On the single-track section west of South Acton this would avoid a conflict with the schedule of extended Train 455. The departure time of extended Train 456 would have to be at least 40 minutes later than at present to avoid a conflict with the schedule of present Fitchburg outbound Train 417.

In order to provide arrival times at points west of South Acton earlier than could be done with an extension of Train 453, it would be necessary to add an entirely new outbound trip. As discussed above, if the layover point of any of the equipment sets now used on the line was shifted from east Fitchburg to Boston but present inbound schedules were maintained, the only feasible new outbound service would have to leave Boston too early in the morning to be useful. A new train leaving Boston at about 6:45 A.M. and making limited stops to South Acton would arrive at the latter at about 7:25 and at Fitchburg at about 8:05. the same equipment would then be available to use on an extended Train 454 if Train 453 were also extended to Fitchburg.

In conclusion, provision of two or three outbound A.M. peak trains to each station west of South Acton would require the assignment of one additional train set to the Fitchburg Line. The capital cost of this set would be about \$11,000,000. Two trips would be run by replacing South Acton short-turns with Fitchburg trains, and the third would require addition of a Boston - Fitchburg round trip. The total added operating cost would be about \$2,240,000 a year. The added service would also require some adjustments in schedules of present trains, resulting in less convenient arrival or departure times for some riders. Alternatively, it would require installation of more passing sidings between South Acton and Ayer, at a cost of \$3,000,000 or more each.

Historically, none of the cities and towns west of South Acton have employed large numbers of Boston residents. The 1990 Census showed that Littleton, Ayer, Shirley, Leominster, and Fitchburg attracted 99, 24, 0, 9, and 50 work trips from all of Boston. With proportional shares of changes in employment, by 1999 Boston jobs in these towns would have increased very slightly or decreased. Reverse commuting service with three trains in each peak could be expected to attract no more than about 50 new riders a day each way. This would not justify the increased operating cost or the cost of the added rolling stock needed for such service.

West of South Acton - P.M. Peak Service

West of South Acton, Littleton / Route 495 is served at 3:32 by inbound Train 424, but times at other stations range from 3:05 at Fitchburg to 3:24 at Ayer. These times would

be too early for most trips home from work. The next trip after that, Train 434, stops at all stations after the end of the P.M. peak. Implementation of more inbound P.M. peak service at these stations would be worthwhile only if outbound A.M. peak service were provided, since most commuters who leave work during P.M. peak hours start work in the A.M. peak.

At present, two inbound P.M. peak trips originate at South Acton. These are Train 466, leaving at 4:17, and Train 468 leaving at 5:07. The equipment for Train 466 turns from outbound Train 465, which arrives at South Acton at 3:55. If Train 466 originated at Fitchburg and maintained the present schedule east of South Acton, it would have to leave Fitchburg at about 3:42. There is currently no equipment in Fitchburg at that time. To provide it, a new outbound train leaving Boston at about 2:00 would be needed. It could be run with the same extra train set needed for outbound A.M. peak service.

The equipment from Train 465 would no longer need to turn back at South Acton to become Train 466, so it could be run through to Fitchburg, arriving there at about 4:34. This would require the schedule of extended Train 466 to be set back by about 10 minutes because of the single track west of South Acton. The equipment for Train 468 turns from outbound Train 467, which arrives at South Acton at 4:56. If Train 468 were extended to Fitchburg, it would have to leave there at 4:42 to maintain the present schedule east of South Acton. The equipment from an extended Train 465 would be available for an inbound departure at about 4:44, which would be close enough.

The equipment from Train 467 would no longer need to turn back at South Acton to become Train 468, so it could be run through to Fitchburg, arriving there at about 5:35. This would, however, require the schedule of the extended Train 468 to be 20 minutes later than its present time east of South Acton because of the single track west of there.

At present, inbound Train 472 leaves South Acton at 6:40 P.M. using equipment from outbound Train 471, which arrives there at 6:28. The equipment from extended Train 467 would be available for a departure from Fitchburg after 5:45. This could be used for an extension of Train 472, which would need to leave Fitchburg at 6:05 to maintain the present schedule east of South Acton. The equipment from Train 471 would no longer need to turn back at South Acton to become Train 472, so it could be run through to Fitchburg, arriving there at about 7:05. This would, however, conflict with the schedule of an extended Train 472 on the single-track segment. One solution would be to advance the Fitchburg departure time of Train 472 from 6:05 to 5:50 with departure times at all subsequent stations also being moved up by about 15 minutes. Most passengers on the present segment of Train 472 would be making non-work trips, and an earlier departure time would allow more time for activities in Boston.

In order to end the service day with the same number of equipment sets at each location as there were at the start, the extension of Train 471 to Fitchburg would require either operation of an additional train from Fitchburg at some time in the evening, or running of a "double-draft" with two train sets coupled together. (This is currently done on some other lines where inbound and outbound service requirements do not balance.) It

would not be practical to terminate Train 471 at South Acton and hold the equipment there for a new evening departure, because there is no place there for a train to clear the main track for other trains. The total cost of providing three inbound P.M. peak trains at all stations west of South Acton would be about \$2,200,000 if the equipment from Train 471 was returned to Boston in a double draft, or \$2,760,000 if a separate trip was run. The capital cost of the added train is included in the A.M. peak calculations.

Detailed Analysis - Framingham/Worcester Line

A.M. Peak Service

At present (Spring 2001), in the A.M. peak two outbound trains leave Boston for Framingham and two leave for Worcester. The Framingham trains both complete their trips well before 9:30. The first Worcester train, which has been running only since April 30, 2001, stops only at Framingham, Grafton, and Worcester after Back Bay, and is due in Worcester at 8:05. The second Worcester train reaches all stations west of Wellesley Square after 9:30. All four trains pass through the Newton stations (Newtonville, West Newton, and Auburndale) without stopping. This is mainly a result of the platform configuration there. The line has two tracks, both signaled for operation in either direction, but only the more southerly track (Track 2) has platforms at any of these stations. Narrow boardwalks across Track 2 allow passengers to access trains stopped on Track 1, but this practice is avoided whenever possible. To serve Boston-bound commuters, all inbound A.M. peak trains normally run on Track 2. Trains can change tracks at crossovers at a location known as (Controlled Point) -11 between Auburndale and Wellesley Farms. Schedules are also constrained by a single-track segment past the Beacon Park freight yards in Allston (from CP-3 to CP-4).

Since April 30, 2001, the first outbound A.M. peak trip has been Worcester Train 503, leaving South Station at 6:50, and running non-stop from Back Bay to Framingham. Train 503 leaves South Station 10 minutes before Framingham Train 505, which stops at all stations from Wellesley Hills to Framingham. If Train 503 were to stop at any of those stations, most of the riders would be diversions from Train 505 rather than new riders. If Train 503 stopped at the Newton stations or Wellesley Farms, none of which are now served by Train 505, the added running time would result in Train 505 beginning to overtake Train 503 and possibly being delayed by it. Arrival times for Train 503 at added stops would range from about 7:08 at Newtonville to about 7:18 at Wellesley Farms. Most reverse commuters would find these times too early.

Train 503 is scheduled to arrive at Worcester at 8:05, with the equipment turning to provide inbound Train 516 leaving at 8:20. The added running time from new stops would reduce the time between scheduled arrival and departure at Worcester to less than the needed minimum of 10 minutes, so Train 516 would have to be given a slightly later departure time there. The equipment for Train 503 is previously used on a train arriving at South Station from another line at 6:20. This would theoretically allow Train 503 to leave earlier than the present 6:50, but that would result in schedule conflicts with inbound trains further out on the line. (Train 503 would have to use Track 2

through Newton to serve the stations there.) Overall, the advantages to having Train 503 serve more stations than it does now would not outweigh the disadvantages.

The second outbound A.M. peak trip is now Framingham Train 505, leaving South Station at 7:00 and running non-stop from Back Bay to Wellesley Hills. This train uses equipment from a train from another line due at South Station at 6:40. Departure time is constrained by this and by the need to meet inbound Worcester express Train 502 (formerly 552) at one end or the other of the single-track segment past Beacon Park. Train 505 uses Track 1 through Newton and beyond and passes CP-11 about two minutes before inbound Framingham Train 504 is scheduled to pass it on Track 2.

Running Train 505 through Newton on Track 2 stopping at all three stations and then crossing to Track 1 at CP-11 would require that the schedule of Train 504 be made about six minutes later than at present. This would put it only nine minutes ahead of inbound Worcester local Train 506 (former 556) instead of the present 15 minutes. Train 505 passes through Wellesley Farms without stopping at about the same time that inbound Train 504 is supposed to be stopped there. Most passengers going between the Track 1 platform there and the parking lot or points further south walk across both tracks. Having Train 505 skip Wellesley Farms avoids the hazard of passengers for or from that train crossing in front of Train 504.

The third outbound A.M. peak trip is now Framingham Train 507, leaving South Station at 7:35 and running non-stop from Back Bay to Wellesley Hills. About two miles east of Newtonville, Train 507 on Track 1 is scheduled to pass inbound Train 506 (former 556) running on Track 2 after stopping at the Newton stations. This precludes the use of Track 2 by Train 507 and prevents it from serving the Newton stations. Train 507 passes through Wellesley Farms without stopping. If it did stop there, it would depart at about 7:58, only two minutes before Train 558 from Worcester is due to pass through the station without stopping. As with the case of Train 505, having Train 507 skip Wellesley Farms avoids having passengers crossing Track 2 in front of an inbound train.

The fourth outbound A.M. peak trip is now Worcester Train 509 (former 559), leaving South Station at 9:00, and running non-stop from Back Bay to Wellesley Farms. About 1.5 miles east of Newtonville, Train 509 on Track 1 is scheduled to pass inbound Worcester Train 516 running on Track 2. Train 516 runs non-stop between Natick and Back Bay. If Train 509 were run on Track 2 to serve the Newton stations, Train 516 would have to use Track 1 between CP-11 and CP- 4. This would result in a slight increase in running times for both trains to change tracks at CP-11. At present, Train 509 has no conflict at Wellesley Farms, so it is the first outbound train of the day to stop there. If it were to stop at the Newton stations, arrival times there would range from about 9:18 at Newtonville to 9:24 at Auburndale. These times would be too late for most reverse commuters.

In order to eliminate the constraint on scheduling service to Newtonville, West Newton, and Auburndale that is imposed by having platforms only on Track 2, it would be necessary to provide platforms on Track 1 at those stations. This would require major

reconstruction of the stations, including the addition of wheelchair accessibility. The latter would require elevators, because platforms at all three stations are too far below street level to reach with ramps. The cost of modifying each station would be at least \$2,000,000.

The three Newton stations are all located in commercial areas, but there are no large individual employment locations near any of them. Alternate transit service from Boston is provided to the vicinities of all three stations by MBTA express bus routes from downtown Boston via the Mass. Turnpike. The bus service is much more frequent than train service would be even if all outbound trains stopped at the Newton stations, and running times on the buses are similar to what the train times would be. Auburndale Station is also within walking distance of the Riverside Green Line terminal. For these reasons, provision of outbound A.M. peak commuter rail service to the Newton stations would attract too few new transit riders to justify the cost of the needed station modifications.

The problem of passengers crossing the tracks at Wellesley Farms could be eliminated if a center-line fence were installed and passengers were required to use the existing road overpass at the east end of the station. This would, however, inconvenience passengers alighting from outbound trains on Track 1 and going to the parking lot on the Track 2 side. Wellesley Farms Station is in a predominantly residential area with few nearby employment opportunities, so the limited outbound A.M. peak service probably has little effect on ridership.

At present the only outbound train arriving at stations west of Framingham during the A.M. peak is Train 503. This train, which began operating on April 30, 2001, has scheduled arrival times of 7:55 at Grafton and 8:05 at Worcester. A tentative schedule for service after the opening of all the new stations shows three outbound trains arriving in Worcester at 6:34, 8:09, and 8:54 A.M. The first of these would be provided by extending Framingham Train 501. That train currently runs non-stop from Back Bay to Framingham. It is due at Framingham at 6:00, and would get to all stations east of Worcester before 6:30, the start of the A.M. peak as defined for this study.

The schedule of the second trip would differ only slightly from that of present Train 503. The third trip would be provided by extending Framingham Train 507, and it would reach all stations during the A.M. peak. At present, Train 501 runs with a double train set, bringing the equipment for both Train 500 and Train 504 to Framingham. The equipment from Trains 507 now turns to provide inbound Train 514. These three inbound trains had peak loads of 533, 737, and 337 riders in Spring 2000, which is much greater than the potential reverse commuting ridership to stations west of Framingham. Therefore, extension of Trains 501 or 507 to Worcester would have to wait until additional equipment was available to replace the inbound trips they now rotate to.

The tentative schedule also calls for four inbound trains from Worcester arriving in Boston in the A.M. peak, on about the same schedules as the present one. Three of these would use train sets kept overnight at the layover facility near Worcester Station, as

they do now, but the first of the three outbound trains would provide equipment for the second inbound A.M. peak trip. If another of the Worcester sets were based in Boston, it could be used to provide an additional outbound A.M. peak trip. The most useful time would be a train leaving Boston at about 6:15, arriving in Worcester at about 7:30, and providing the equipment for the inbound train now departing at 7:42. The main operational problem for this trip would be coordination with CSX through freight trains arriving from western states in the early morning. The added operating cost of changing the basing point of one train set from Worcester to Boston would be about \$525,000 per year, assuming that the set was returned to Boston coupled to another train at the end of the day to position it for the next morning.

Prior to February 2001, there was no service suitable for reverse commuting to stations west of Framingham. From February to April 2001, there was a train leaving Boston at 4:55 A.M. and due in Worcester at 6:15, but it was too early for most reverse commuters, and it did not stop at Grafton. The present Train 503, due at Grafton at 7:55 and Worcester at 8:05, has been running only since April 30, 2001. Stations west of Framingham other than Grafton and Worcester are still under construction. At this time there are no base-case numbers from which to estimate ridership for expanded reverse-commuting service.

As of 1990, Worcester employed the greatest number of Boston residents of any community on this line west of Framingham, with 270. Westborough was second, with 223. Southborough, Ashland, and Grafton were all far behind, with 67, 41, and 15. With proportional shares in employment growth, the Boston totals to Worcester, Grafton, and Ashland would not have changed significantly by 1999. The figure for Westborough would have increased to about 275, and that for Southborough to about 90. The reverse commuters in 1990 came predominantly from outlying Boston neighborhoods. Based on typical commuter rail travel shares, three outbound A.M. peak trains would be expected to carry a total of about 110 reverse commuters to all stations combined west of Framingham, or about 30 to 40 per train. A new outbound A.M. peak train for stations west of Framingham could also add a third trip at Natick and West Natick. Based on current outbound A.M. peak alightings at those stations, a third train would carry a total of about 25 riders to them.

P.M. Peak Service

The present P.M. peak schedule has inbound trains leaving Framingham at 3:45, 5:40 and 6:30. Since April 30, 2001 there has also been one inbound P.M. peak train leaving Worcester at 5:35. The 3:45 Framingham train stops at all intermediate stations. The two later Framingham trains and the Worcester train make all stops up to Wellesley Farms and then run non-stop to Back Bay. The latest of these (Train 532) reaches all stations after Framingham later than 6:30. The practice of having the second inbound P.M. peak train (Train 528) omit the Newton stations dates from a time when this train left Framingham earlier and reached Newton before the 5:30 outbound local train was clear of Track 2 at CP-11. The present schedule would not have such a problem, but the running time added by the Newton stops would require a slight additional adjustment

so that Train 528 would pass outbound Worcester express Train 529 west of CP-4 instead of between CP-3 and Back Bay as it now does.

Under the future schedule with full Worcester service, Train 524 might once again be unable to stop at the Newton stations. Full Worcester service is expected to be implemented within the next two years, so it would be confusing for passengers to add Newton stops that would have to be dropped again soon. As is the case in the morning, there is alternate transit service between the Newton stations and Boston provided by MBTA express buses.

The tentative P.M. peak schedule from west of Framingham will have three or four inbound trains each at Worcester, Grafton, and Westborough. The latest of these trains would leave Southborough and Ashland after 6:30. Reverse commuting potential from the immediate vicinities of the latter two stations is very low. A departure slightly later than 6:30 could be preferable for passengers requiring connecting transportation to the stations from more distant work locations.

Service to Yawkey Station

Summary of Station Location and Service

Yawkey Station is located on the Framingham / Worcester Line 2.5 miles from South Station in the Fenway neighborhood of Boston. Prior to January 2001, it was a special-purpose station, served only by trains that stopped close to the starting and ending times of baseball games at nearby Fenway Park. Regular stops by four weekday trains in each direction, including two inbound A.M. peak and two outbound P.M. peak trips were implemented in January 2001. Service was further expanded on April 30, 2001. At this writing, the weekday schedule includes stops by seven trains in each direction, including two inbound A.M. peak and by two outbound P.M. peak Framingham trains and one outbound P.M. peak Worcester train. There is no outbound A.M. peak service, but both inbound trains that pass Yawkey Station in the P.M. peak stop there, at 4:20 and at 6:15.

The present Yawkey station has a platform only on Track 2. Trains stopping there must run on Track 2 at least between Cove, east of Back Bay, and CP-3, at the east end of the Beacon Park freight yards. At present, four outbound trains run past Yawkey Station in the A.M. peak, all on Track 1. These are Trains 503, 505, 507, and 509, which pass Yawkey at about 7:00, 7:10, 7:45, and 9:10.

Potential for Expansion of Reverse Commuting Service

Inbound Train 500 stops at Yawkey at 6:52 A.M., and passes Train 503 between there and Back Bay. Train 503 could not stop at Yawkey unless it left Back Bay about five minutes later than it now does, but that would put it too close to the time of Train 505. At present, Train 505, running on Track 1 passes Yawkey at about the same time that inbound Train 502 passes it on Track 2 without stopping. Reversing the track assignments of these two trains would allow Train 505 to stop at Yawkey, and would not cause any other conflicts.

Inbound Train 504 stops at Yawkey at 7:37 A.M., and passes Train 507 between there and Back Bay. In order for Train 507 to stop at Yawkey, South Station departure time would need to be delayed by at least six minutes from the present 7:35. The Yawkey stop itself would add another minute. These delays would create a new conflict with the schedule of inbound Train 506, requiring a further delay of four minutes for Train 507. With no additional delays, it would arrive at Framingham at 8:28. The equipment from Train 507 is used on inbound Train 514, which now leaves Framingham at 8:30, but could not leave until at least 8:38 with the later arrival of Train 507. Prior to April 30, 2001, Train 514 left at 8:45, but it was shifted to 8:30 to provide better separation from new Train 516 from Worcester which was started then.

At present, Train 509, running on Track 1, passes inbound Train 514, running on Track 2, between Back Bay and Yawkey. Neither train now stops at Yawkey. Reversing the track assignments of these two trains would allow Train 509 to stop at Yawkey, and should provide enough time for Train 509 to get past CP-4 before inbound Train 516 was due there.

In summary, with some changes in track assignments, it would be feasible for two outbound A.M. peak trains (Trains 505 and 509) to stop at Yawkey station. It would not be feasible for the other two outbound A.M. peak trains (Trains 503 and 507) to stop there without causing unacceptable disruptions to schedules of these and other trains.

Present Ridership

Even if reverse commuting service were available at Yawkey, ridership from suburban homes to Boston work or school locations would be expected to account for most of the traffic there. A one-day CTPS count at Yawkey in May 2001 found a total of 31 passengers boarding the three outbound P.M. peak trains and another four boarding the 7:23 P.M. train. The 4:38 Framingham train, which had been running since January, had the most boardings, at 15. The 5:13 and 5:38 trips, which had been running for only one week, had eight boardings each. This probably included some former riders of the 6:25 train, which no longer stopped there. Most of the riders approached the platform from the direction of the Harvard Pilgrim Health Care center on Brookline Avenue.

The two inbound P.M. peak trains had a total of three boarding passengers, all on the 6:15 trip, which replaced a 6:05 trip. Alightings in both directions consisted mostly of ballgame patrons. The three outbound P.M. peak trains had a total of 10 alightings. The 4:38 trip, which had been running since January, had none. The two new trips (5:13 and 5:38) had six and four alightings. (The new 7:23 inbound trip also had none.)

The inbound Framingham trains arriving at 4:20 and 6:15 make all of their prior stops during the P.M. peak. The new 6:43 Worcester train makes all of its prior stops before 6:30 except at Wellesley Farms, which it reaches at 6:32. These three trains had a total of 198 offs at Yawkey, with the greatest number being 141 from the 6:15 trip. The earlier and later trains had 17 and 40 offs respectively. There were another 18 offs at 7:05 from Framingham Train 532, which makes a special stop only for evening ballgames. (It reaches all stations east of Framingham after 6:30.)

Comparisons with Ruggles Reverse Commuting

Yawkey Station is somewhat comparable to Ruggles Station, which is 2.2 miles from South Station on the Attleboro/Stoughton, Franklin, and Needham Lines. Yawkey Station is within walking distance of Boston University and portions of the Longwood Medical Area, and also has bus connections to the latter. Ruggles is within walking distance of Northeastern University, Wentworth Institute, and Mass. College of Art. Like Yawkey, it is within walking distance of portions of the Longwood Medical Area, and also has bus connections to the latter. At present, the platform configuration at Ruggles limits outbound A.M. peak service to only three trains, and inbound P.M. peak service is not feasible.

At Ruggles, much more frequent service for reverse commuters is provided by the Orange Line, which also serves Back Bay Station directly and has connections from South Station via the Red Line. There is no direct rapid transit service to Yawkey, but the Kenmore Green Line station is about one quarter mile away. The Green Line provides direct service from Copley Square, a short distance from Back Bay, and has connections from South Station via the Red Line.

In Spring 2000 counts, the second and third outbound A.M. peak trains stopping at Ruggles each had either one alighting or none there on two different days. Alightings from the first train ranged from 10 to 18 in four observations, but most of these appeared to have transferred at Back Bay from an inbound Franklin train that doesn't stop at Ruggles. These findings suggest that Yawkey Station would also be an outbound alighting point for very few reverse commuters even after service was well established.

Yawkey could also be used as a boarding location for reverse commuters going to points further west in the A.M. peak, but again the experience at Ruggles suggests that demand would be low. Only three to nine passengers boarded each of the three outbound A.M. peak trains stopping at Ruggles in the Spring 2000 counts.

Detailed Analysis - Needham Line

A.M. Peak Service

At each Needham Line station that has only two outbound A.M. peak trains, a third train passes through without stopping. At Forest Hills, Trains 605 and 607 stop, but Train 609 does not. There is no obvious operational reason why Train 609 could not also stop at Forest Hills. A Spring 2000 count showed only one passenger alighting from Train 607 there, but five boarding. Much more frequent service to Forest Hills from downtown Boston is provided by the Orange Line, so Train 609 would probably also have few riders there if a stop were added.

At Roslindale, Bellevue, and Highland, Trains 605 and 609 stop but Train 607 does not, Train 607 leaves Forest Hills only 17 minutes after Train 605. After stopping at West Roxbury, Train 607 goes into a passing track to wait for inbound Train 604, which is due

at West Roxbury 11 minutes after Train 607 departs. The wait adds 10 minutes to the usual outbound running time between West Roxbury and Hersey. Based on the schedules of other trains, adding stops at Roslindale, Bellevue, and Highland on Train 607 would delay its departure from West Roxbury by about four minutes. This should still allow enough time to get clear in the passing track before Train 604 leaves Hersey.

The neighborhoods served by Roslindale, Bellevue, and Highland all have frequent bus service from the Orange Line at Forest Hills. Because of this and the short interval between Trains 605 and 607, Train 607 would probably serve few new riders at these stations. Recent counts have not been done there for the trains that do stop. When CTPS counts were done in 1994, Train 605 stopped at all three stations, but had no alightings at Bellevue or Highland, and only one at Roslindale. Train 609 stopped at Roslindale but not at the other two. Alightings from Train 609 were not recorded.

Although some stations currently have three outbound A.M. peak trains, the short interval between Trains 605 and 607 limits flexibility in travel times. There are currently five inbound A.M. peak trains, of which the first three use equipment sets that are kept overnight at Needham Heights, and the last two use equipment that turns back from the first two outbound trains. If the equipment for the third inbound train were also kept in Boston, it would have to arrive at Needham Heights no later than 7:24 to maintain the present inbound schedule. With stops at all stations, this would require a South Station departure no later than 6:39.

Because of the many single-track sections in the line, changes to schedules of trains in one direction usually require changes in schedules of one or more trains in the opposite direction. Schedules of Needham trains also must be compatible with those of other trains using the tracks between South Station and Forest Hills. To avoid conflicts with the schedules of inbound Needham Trains 605 and 607, and with those of several main line trains, the most feasible schedule for a new outbound trip would result in a Needham Heights arrival at 7:28, which would in turn require a four-minute later start for Train 604. This could actually improve outbound service, as it would allow Train 607 to meet Train 604 at Needham Junction instead of West Roxbury, if Train 607 still skipped the same stations that it does now. Planned expansion of intercity Amtrak service may soon preclude addition of another outbound Needham train, however. Spring 2000 counts showed that the first two outbound Needham trains each carried about 25 riders leaving Back Bay, and the third carried about 35. This suggests that ridership on a train leaving South Station even earlier than the present first one would also carry fewer than 25 riders. The added operating cost of basing the equipment for Train 604 in Boston instead of at Needham Heights would be about \$170,000 a year, assuming that the equipment would be returned to Boston coupled to another train at the end of the service day.

P.M. Peak Service

At present, inbound Trains 618 and 620 stop at all stations on the Needham Line. Train 622 stops at all stations except Highland, Bellevue, and Roslindale. Train 622 meets

outbound Train 625 at Forest Hills Station. The double track at the station continues west for only 0.8 miles, so the running time of Train 622 could not be lengthened much without delaying Train 625. At present, however, the scheduled time for Train 622 from leaving West Roxbury to leaving Forest Hills is the same as that for trains that make all three intermediate stops. Unless Train 622 is late, it must wait for time at Forest Hills, so the added stops would not usually delay it. As in the morning, however, it is probable that few new riders would be served by adding these stops.

Detailed Analysis - Franklin Line

Summary of Present A.M. Peak Service

At present, the Franklin Line has seven inbound A.M. peak trains, including five originating at Forge Park between 5:45 and 7:45, one originating at Walpole at 7:52, and one originating at Norwood Central at 8:46. There are also four outbound A.M. peak departures, including one each to Walpole and Norwood Central and two to Forge Park. None of the outbound trains stops at every station it passes through, and the second Forge Park Train arrives at several stations after 9:30. Of the five inbound Forge Park trains, the first three use rolling stock that is kept overnight at a layover facility near Franklin Station. The other two use sets that are kept overnight in Boston and are run out from Boston coupled together in one non-revenue train before the start of the A.M. peak. The inbound trains from Walpole and Norwood Central each use equipment turning back from the outbound revenue trains to those points.

Feasibility of Adding Stops by Walpole Train 793

At present, the outbound Walpole train (Train 793) runs via the Dorchester Branch, and makes intermediate stops only at Readville (discussed under the Fairmount Line), and Norwood Central. Train 793 is scheduled to arrive at Walpole only 11 minutes before the equipment is supposed to depart as inbound Train 738. This margin is too short to allow for any additional outbound stops without changing departure times of one train or the other. The equipment for Train 793 is used previously on inbound Fairmount Line train 744, which is due at South Station only 12 minutes before the departure of Train 793. There are no other train sets free in Boston at that time, so the starting time of Train 793 could not be made enough earlier to allow for additional stops.

Train 738 leaves Walpole only 13 minutes ahead of Train 710 from Forge Park. Spring 2000 counts showed that both trains were heavily patronized, with Train 738 carrying a slightly greater total number of riders. A delay in the departure time of Train 738 would be likely to result in shifting of some riders from Train 710, worsening the load imbalance between the two trains. In conclusion, it would not be feasible to have Train 793 serve more stops than it now does.

Feasibility of Adding Stops by Norwood Central Train 735

The outbound Norwood Central train (Train 735) runs via Back Bay and made no stops between there and Norwood Central prior to April 30, 2001, when a stop at Norwood Depot was added. Train 735 is scheduled to arrive at Norwood Central only 13 minutes before the equipment is supposed to depart as inbound Train 792. This margin is too short to allow for more than one additional outbound stop without changing departure times of one train or the other. The scheduled running time was not increased when the Norwood Depot stop was added, so unless there was slack in the old schedule, arrival at Norwood Central may now be late. The equipment for Train 793 is used previously on inbound Worcester Train 552, which is due in South Station 49 minutes prior to the departure of Train 735. This should theoretically allow Train 735 to depart earlier and make more stops while maintaining the departure time of Train 792. The greatest number of intermediate stops that would be likely to be added should add at most about 10 minutes to the running times. This would require that South Station departure time be changed from 8:09 to about 7:59.

Spring 2000 counts showed that the heaviest component of ridership on Train 735 was 40 riders going only from South Station to Back Bay, compared with a total of 18 going from these stations to Norwood Central. Many of those going to Back Bay probably transferred from a Kingston train due at 8:06. If the departure of Train 735 was made earlier, the Back Bay transfer riders would have to wait for the 8:30 South Attleboro train or use another means of transportation.

The additional stations that could be served by Train 735 are Readville, Endicott, Dedham Corporate Center, and Islington. Arrival at Readville would be only one minute ahead of that of Fairmount Line train 751, which had only three alightings there in a Spring 2000 count. Train 735 would add the possibility of travel from Back Bay to Readville, but the number of riders wanting to make that trip would also be expected to be very small.

Endicott Station is in a mostly residential neighborhood, with little potential for attracting reverse commuters. At present the first outbound train stopping there is due at 9:28 A.M. Observations of that train on two days in Spring 2000 found three Endicott alightings on one day and none on the other.

Train 735 would arrive at Dedham Corporate Center about eight minutes after Franklin Train 795, which had 12 alightings there in a Spring 2000 count. Train 795 does not stop at Back Bay, so Train 735 could serve some new riders going to Dedham Corporate Center from there, but few new riders from South Station would be gained with such closely spaced arrivals. Train 707, arriving at Dedham Corporate Center at 9:30, had seven alightings there on one day in Spring 2000 but only one on another day.

Islington currently has no outbound A.M. peak service, so it is difficult to estimate how much ridership might be attracted if Train 735 stopped there. The station is within walking distance of some large employers, but Westwood overall attracts far more

workers from outlying residential neighborhoods of Boston than from downtown. The only possible Boston boarding point outside downtown would be Readville. The general vicinity of Islington can be reached by MBTA bus Route 34E from Forest Hills. This route has outbound A.M. peak headways of 10 to 20 minutes.

The recent addition of a stop by Train 793 at Norwood Depot provides the only outbound A.M. peak service at that station. It has not been operating long enough to evaluate ridership potential. Norwood depot is within walking distance of some large employers, but like Westwood, Norwood overall attracts far more workers from outlying residential neighborhoods of Boston than from downtown. The general vicinity of Norwood Depot can be reached by MBTA bus Route 34E from Forest Hills. Also, Norwood Depot is only one half mile from Norwood Central.

In conclusion, although it would be technically feasible for Train 735 to serve more stations, the inconvenience to riders who could no longer use it to travel from South Station to Back Bay would probably outweigh the benefits for new reverse commuters.

Feasibility of Adding Stops by Forge Park Train 795

Forge Park Train 795 runs via the Dorchester Branch, but does not stop until it reaches Dedham Corporate Center. The next stop after that is Norwood Central, with all stations from there to Forge Park being served except Plimptonville. Train 795 leaves South Station five minutes ahead of Fairmount Line Train 751, which had only three alightings at Readville in a Spring 2000 count. Therefore, there would be little benefit in having Train 795 stop at Readville except possibly to pick up riders. As discussed above for Train 735, ridership potential at Endicott, Islington, and Norwood Depot would also be low.

Plimptonville, the only station south of Norwood Central not served by Train 795, is about one mile from the nearest large employers. Even if reverse commuting trains stopped at Plimptonville, these employers would still be served more directly by bus Route 34E. The only outbound A.M. peak train other than Train 795 that passes through Windsor Gardens or Plimptonville without stopping is Walpole Train 793. As discussed above, there is insufficient slack in the schedule to allow Train 793 to make any more stops than it does now.

Feasibility of Adding More Trains on Outer End of Line

No A.M. peak trains pass through Norfolk, Franklin, or Forge Park without stopping, so increasing reverse commuting service at those stations would require running more trains. At present, the three trains that use equipment based in Franklin leave Forge Park between 5:45 and 6:35 A.M. If these trains instead used equipment turned back from new outbound trips, those trips would have to leave South Station no later than 4:40, 5:10, and 5:30. Very few riders would find these times useful, especially since there would be no connecting service to the downtown Boston boarding stations from most residential areas that early.

The double set with equipment for Trains 708 and 710 leaves the yards in Boston at about 3:45 A.M., and arrives at Forge Park at about 4:35, but Train 708 does not leave until 7:00, and Train 710 does not leave until 7:45. The reason for the very early departure is to avoid schedule conflicts with inbound trains on single-track segments of the line. If this were not an issue, Train 708 could theoretically turn from a new outbound train leaving Boston at about 5:55 A.M. and Train 710 could turn from a train leaving at about 6:40. The Franklin Line is entirely single track from Norwood Central to Forge Park except for a passing siding just south of Walpole Station. It is also possible to use the Franklin layover tracks to get a train clear of the main line. An outbound train leaving Boston at 5:55 A.M. would arrive at Walpole at 6:30, but inbound Train 704 does not clear the track south of there until 6:35. Delaying the outbound train five minutes would not allow it to reach Franklin before inbound Train 706 is supposed to leave there. Trains 706 and 708 would both have to be given later departure times, since the new train would not arrive at Forge Park in time to turn to the present Train 708 schedule. A 6:00 departure from Boston and a 6:55 arrival at Forge Park would still be too early to attract many reverse commuters.

An outbound train leaving Boston at 6:40 A.M. would arrive at Walpole at 7:15, but inbound Train 708 on its present schedule does not clear the track south of there until 7:21. If Train 708 used equipment from another new outbound train as discussed above, it would not reach Walpole until at least 7:28, but it would still leave Franklin long before an outbound 6:40 train could get there. To eliminate this conflict, the outbound departure time would have to be advanced to 6:20, and inbound Train 706 on its present schedule would be met at Walpole. Arrival at Forge Park would be at 7:12, still too early for most reverse commuters, and arrivals at intermediate stations would be even earlier. Running the equipment for Trains 708 and 710 out of Boston in separate revenue service trains instead of in a non-revenue double set would increase operating costs by about \$375,000 a year.

Adding new outbound trips other than with the equipment for Trains 708 or 710 would require additional train sets, since none are now available at useful times. A new train leaving Boston at 7:00 A.M. could get to Forge Park at about 8:00, passing Train 708 at Norwood Central and Train 710 at Franklin. This equipment would be available to run a new inbound train leaving Forge Park at about 8:10. It would leave Norwood Central a few minutes ahead of Train 792, and could make limited stops from there to South Station where it would arrive at about 9:05.

A new outbound train at 7:00 would stop at the same stations as the present 7:50 train (Train 795) possibly with some additions. A Spring 2000 count on Train 795 found 37 passengers boarding at South Station, of which 12 went Dedham Corporate Center and 25 to all other stations beyond that. Ridership on a new 7:00 train would be expected to be similar. Some of the riders would be diverted from Walpole Train 793, which leaves South Station at 7:05 and stops only at Readville, Norwood Central, and Walpole. That train had 24 boardings in the Spring 2000 count but destinations were not determined. Train 793 would still need to be run to provide equipment for the heavily patronized inbound Train 738.

The capital cost for a new six-car train set for an additional Franklin train would be about \$12,800,000. The annual operating cost of one additional A.M. peak round trip would be about \$715,000.

Summary of Present P.M. Peak Service

At present, the Franklin Line has six outbound P.M. peak trains, including four departing for Forge Park between 4:10 and 6:15, one to Franklin Station leaving at 4:30, and one to Norwood Central leaving at 4:50. There are also three inbound P.M. peak trains, including two from Forge Park and one from Norwood Central. None of the inbound trains stops at every station it passes through. The outbound train to Franklin Station (Train 797) and the second train to Forge Park (Train 719) make the last trips of the day with their equipment sets and then proceed to the Franklin layover facility for the night. The first Forge Park train (Train 715) turns immediately to return as the last inbound P.M. peak trip (Train 798). The equipment from the last two Forge Park trains (Trains 721 and 723), which both arrive there after the end of the inbound P.M. peak, is coupled together and returned to Boston in the early evening as Train 724. Equipment from the Norwood Central train (Train 737) returns immediately as Train 796, stopping only at Dedham Corporate Center between Norwood Central and South Station.

Neither of the inbound Forge Park trains stops at Plimptonville. Train 720 stops at Windsor Gardens, but Train 798 does not. Norwood Central and Dedham Corporate Center are the only stations served by all three inbound P.M. peak trains. Norwood Depot is not served by any of them. Readville is served only by Train 720 from this line but is also served by Fairmount Line trains.

Feasibility of Adding Stops by Trains 720, 798, or 796

From an operations standpoint, there is no obvious reason why Trains 720 and 798 could not stop at all stations that they pass through. Running times would increase by a few minutes, but this would not interfere with the meeting points with any outbound trains. The slightly later arrivals at South Station would have no impact on the rotation of the equipment to the next outbound assignments. In contrast, the equipment from Walpole Train 796 is scheduled to go out on a Framingham train 11 minutes after arriving at South Station. Any additional stops between Walpole and Boston would interfere with this.

Feasibility of Adding Inbound P.M. Peak Trains from Forge Park

The outbound train that terminates at Franklin Station and proceeds to the layover facility (Train 797) does not continue to Forge Park because that would conflict with the schedule of inbound Train 798. It would be possible to have Train 797 continue to Forge Park in non-revenue service and then make a new inbound trip departing at about 6:00. This train would have to meet outbound Train 719 at Franklin and outbound Train 721 at Walpole, possibly resulting in slight delays to each of them. The last station that the new train would reach before 6:30 would be Walpole.

To end the service day with the same number of train sets at Boston and Franklin as at present, the equipment from Train 721 could be left at Franklin instead of being returned to Boston with the equipment from Train 723 in Train 724. The net impact on operating cost of adding an inbound trip with the equipment from Train 797 and leaving the equipment from Train 721 at Franklin would be an increase of about \$440,000 a year.

Train 719 now arrives at Forge Park at 6:15, with the equipment returning from there to the Franklin layover facility. An inbound revenue trip using this equipment could leave Forge park no earlier than 6:25, and would not get to any other station before 6:30.

Adding stops to Trains 720 and 798 and adding a new inbound train from Forge Park at 6:00 would make it possible to have three inbound P.M. peak trains at all Franklin Line stations except Plimptonville, Windsor Gardens, Norwood Depot, Islington and Endicott, which could each have two at most. As discussed in the A.M. peak sections, the major employers nearest Plimptonville are served more conveniently by MBTA bus Route 34E than they would be by having reverse commuting trains stopping there. Windsor Gardens Station adjoins a large condominium complex which it was built to serve, and it is used almost exclusively by residents of the complex. There are no major employers nearby. Norwood Depot and Islington have some employment nearby, but both are near stops on bus Route 34E and Norwood Depot is about one half mile from Norwood Central. Endicott is in a mostly residential area.

A Spring 2000 count on the later of the two inbound P.M. peak Forge Park trains found only one passenger boarding at Islington and two at Endicott. These were probably not reverse commuters. Islington has no outbound A.M. trains suitable for reverse commuting, and Endicott has only one, arriving at 9:28. Spring 2000 counts showed three Endicott alightings from that train on one day, but none on another.

Detailed Analysis - Attleboro/Stoughton Line

Summary of Present A.M. Peak Service

At present (Spring 2001), the Attleboro / Stoughton Line has 11 inbound A.M. peak trains, including four originating at Providence, two at South Attleboro, one at Mansfield, and four at Stoughton. Outbound, there are seven trains, including three to Stoughton, and one each to Mansfield, Attleboro, South Attleboro, and Providence. The two stations with the most reverse commuting service, Route 128 and Canton Junction, are served by some trains going to each of the outer terminals. Neither station is served by every train that passes through it, but each has five trains. Hyde Park is the only station on the line with no outbound A.M. peak service. The rest have one to three trains each.

Feasibility of Providing Outbound A.M. Peak Service to Hyde Park

This line has three tracks between Readville and South Station. At Hyde Park Station the two outer tracks (Tracks 3 and 2) have outside platforms. The center track (Track 1) is an express track with no platform. At least some of the trains that pass through Hyde Park without stopping run on Track 1. For trains running through Hyde Park on a track with a platform, the running time added by making a stop would depend on how many stations on each side were also being skipped, as this affects the maximum speed. The least amount of time added on outbound trips would be three minutes. This would interfere with some trains arriving at their final stations in time to make their next inbound departures.

Alternate service to Hyde Park from downtown Boston is available using a combination of the Orange Line and bus Route 32 or 50 from Forest Hills. There are also less direct connections from the Red Line. Fairmount Station on the Fairmount Line is about one half mile from Hyde Park. It has been observed that some passengers ride inbound trains from Hyde Park but return outbound to Fairmount because schedules there are more convenient. A similar trade-off is also open to reverse commuters, but Spring 2000 counts found no more than three passengers alighting from any outbound A.M. peak train at Fairmount. Five passengers boarded at Hyde Park on the one inbound P.M. peak train for which a count was done. In conclusion, the potential demand for reverse commuting service to Hyde Park Station appears to be insufficient to justify the disruption in schedules of other trains that would result.

Feasibility of Increasing Outbound A.M. Peak Service to Sharon, South Attleboro, and Providence

The only other stations on this line with fewer than three outbound A.M. peak trains are Sharon, South Attleboro, and Providence. Sharon is served by Trains 803 and 805, arriving there at 7:12 and 9:00. New Train 831, which has been running only since April 30, 2001, passes through Sharon at about 7:00 without stopping. This train terminates at Mansfield, where the equipment turns to become new inbound Train 832. The scheduled time at Mansfield Station is 15 minutes, or five minutes longer than the minimum 10-minute allowance for reversing. It appears that it would be feasible to add a stop at Sharon on Train 831 without disrupting service. Arrival time there would be only 12 minutes earlier than that of Train 803, however, so a stop by Train 831 would result in little service improvement. A Spring 2000 count on Train 803 found only three passengers alighting at Sharon.

Train 833 (former 831) passes through Sharon at about 8:23, but does not stop there. This train terminates at Attleboro where the equipment turns to become inbound Train 834 (former 832). The scheduled time at Attleboro Station is 13 minutes, or three minutes longer than the minimum 10-minute allowance for reversing. It appears that it would be feasible to add a stop at Sharon on Train 833 without disrupting service. The arrival time of Train 833 at Sharon would be closest to that of Train 805, at 9:00. The Spring 2000 count on Train 805 was not done as far as Sharon. Fewer riders remained

on board Train 805 than on Train 803 after Route 128 (29 versus 44) but Train 805 terminated at South Attleboro, whereas Train 803 continued to Providence. Nevertheless, it is probable that no more than five passengers alighted from Train 805 at Sharon. Alightings at Sharon from Train 833, if it stopped there, would probably also not exceed five. The 1990 Census found 282 reverse commuting trips to Sharon from Boston, with the majority from outside Boston Proper. The 1993 survey found only two work-to-home trips from Sharon to Boston by rail.

The only outbound trains stopping at South Attleboro in the A.M. peak, as defined for this study, are Train 803 at 7:34 and Train 805 at 9:21. Train 801 is due at 6:20. No trains pass through without stopping. A Spring 2000 count for Train 803 showed eight alightings at South Attleboro, but some may have boarded at intermediate stops after Boston. Counts were not done there for Trains 801 or 805. As noted above, Train 805 had fewer passengers on board after Route 128 than Train 803, but the latter continued to Providence.

In order to provide a third outbound A.M. peak train at South Attleboro, it would be necessary to run a new train either terminating there or continuing to Providence. The latter alternative would be used only if the state of Rhode Island were to fund such an extension. Trains terminating at South Attleboro actually have to continue about three miles further to reach a location where they can change tracks. The shortest scheduled allowance is 13 minutes, and usually at least 20 minutes is allowed between outbound arrivals and inbound departures. Train 833 now turns back at Attleboro Station because there would be insufficient time to continue to the crossovers beyond South Attleboro and still meet the schedule of inbound Train 834.

A train arriving at South Attleboro half way between the times of Trains 803 and 805 would get there at 8:28. To do so, it would have to leave South Station at 7:37 if it had the same running time as Trains 803 and 805. At present, Stoughton Train 907 leaves at 7:40, so the departure time of the new train would have to be made either earlier than 7:37 or later than 7:40 to provide better spacing. A time later than 7:40 would be too close to the departure of Attleboro Train 831 at 7:53. The latest feasible departure time prior to Train 907 would be about 7:35.

The only idle train set in Boston at 7:35 is one from an Old Colony train. This set is not fully compatible with operation on the Attleboro / Stoughton Line because it has remote-controlled outside doors that can be used only at high-level platforms. (There are also potential uses for this set for new outbound A.M. peak service on the Old Colony lines.) The first available set without this limitation is due in Boston at 7:47, and could leave at 7:57 at the earliest. This would be four minutes after the departure of Attleboro Train 833. Therefore, to provide useful additional service, a new outbound A.M. peak train would require an additional train set. A train leaving South Station at 7:35 would arrive at South Attleboro at about 8:26. If it terminated there, the equipment would be available for an inbound departure at about 8:50, but it would then leave Attleboro only four minutes after Train 834.

At present, the only outbound A.M. peak commuter train serving Providence is Train 803, which is due there at 7:43. A Spring 2000 count showed 33 alightings there, but about 20 of these were apparently from boardings at intermediate stations outside Boston. Trip purposes were not determined. Train 801, which leaves South Station at 5:30 A.M., carries passengers only as far as South Attleboro, but then continues in non-revenue service to Providence, arriving there at about 6:30. The equipment then turns to become inbound Train 806, leaving at 7:08. This train could provide a second outbound A.M. peak Providence trip at no additional cost. With the early Boston starting time, it would not be expected to attract many riders from Boston, however, and all stops before Providence would be reached before 6:30. At present, the only Train 801 stops after Back Bay are Mansfield, Attleboro, and South Attleboro. This train should theoretically be able to leave Boston later than it does now and still arrive in Providence in time for the 7:08 departure. It is, however, necessary for it to leave early enough to prevent being overtaken by much faster Amtrak intercity trains. This would require a departure no later than 5:45, which would still result in arrival prior to 6:30 at all stations before South Attleboro.

As discussed above, a train filling the gap in South Attleboro service between Trains 803 and 805 could leave Boston at 7:35. If this train ran through to Providence it would arrive there at about 8:35 and would be available for inbound service after about 8:45. This would put it eight minutes after the time of Train 831 at Attleboro. To add useful service it would need to leave later, but a later departure time is constrained by the schedule of Amtrak Train 190, which leaves Providence about 9:30, but makes fewer stops. A departure after Train 190 would conflict with schedules of other Amtrak and commuter trains

The ridership for a new outbound train for South Attleboro and Providence would be low. The one train observed at South Attleboro in Spring 2000 had eight offs there. The other train had fewer total riders leaving Boston, but did not run through to Providence. As discussed above, the one Providence train had only about 13 riders going there from Boston.

The capital cost of a new six-car train used to add one outbound trip terminating at either South Attleboro or Providence would be about \$12,800,000. The added operating cost of a one-way trip to either terminal would be about \$515,000 a year, because the train would end up at the new layover facility near Providence Station regardless of whether or not it served that station. This amount would double if an inbound trip were also added.

Summary of Present P.M. Peak Service

At present, the Attleboro / Stoughton Line has 11 outbound P.M. peak trains. Of these, four terminate at Stoughton, one at Canton Center, one at Canton Junction, and five at Providence. Inbound there are eight trains making some or all of their stops in the P.M. peak. Of these, two originate at Stoughton, one at Canton Center, two at Canton Junction, one at South Attleboro, and two at Providence. All stations except Ruggles are

served by at least one of these inbound trains. The only other stations on the line with fewer than three inbound P.M. peak trains are Canton Center and Stoughton with one each, and Providence and South Attleboro with two each.

Feasibility of Providing Inbound P.M. Peak Service at Ruggles

At Ruggles, the two westernmost tracks (Tracks 1 and 3) share an island platform, but the third track (Track 2) has none. This line segment is shared with Franklin and Needham Line trains and with Amtrak Northeast Corridor trains. For capacity reasons, most inbound P.M. peak trains normally run through Ruggles on Track 2, preventing them from stopping there. Installation of a platform on that track would be extremely costly, as the track is bounded to the west by the other two tracks and their platform and to the east by a high retaining wall. Ruggles and Back Bay are also connected directly by the Orange Line. Alternate transportation service between Ruggles and South Station is available using a combination of the Orange and Red lines.

In Spring 2000 counts, the second and third outbound A.M. peak trains each had either one alighting or none at Ruggles on two different days. Alightings from the first train ranged from 10 to 18 in four observations, but most of these appeared to have transferred at Back Bay from an inbound Franklin train that doesn't stop at Ruggles. Passengers returning from such a trip could board most outbound P.M. peak Franklin trains directly at Ruggles. In conclusion, the station modifications that would be needed to allow inbound P.M. peak trains to stop at Ruggles could not be justified.

Feasibility of Increasing Inbound P.M. Peak Service at Canton Center and Stoughton

The one inbound P.M. peak train serving Canton Center is Train 978, which originates there using the equipment from outbound Train 977. A Spring 2000 count found 11 passengers boarding this train at Canton Center, but trip purposes were not determined. The one train that serves Stoughton is Train 920, which starts there. It passes through Canton Center without stopping. If it did stop there, running times would increase by about two minutes. After arriving at South Station, the equipment from Train 920 is scheduled to be there for 25 minutes before the next outbound assignment, so an additional stop at Canton Center would not interfere with this. There is also enough slack at Stoughton to allow for an earlier departure if times north of Canton Center need to be maintained.

Train 920 turns at Stoughton from Train 917, which is due there at 5:20. All earlier trains arrive and depart again before the start of the P.M. peak. The next outbound arrival is Train 919, due at 5:59. The equipment turns to Train 922, leaving at 6:42. The earliest it could theoretically leave would be about 6:09. This would, however, require delaying outbound Train 921, which is due at Stoughton at 6:26, by about four minutes at or before Canton Junction. Spring 2000 counts showed 15 passengers boarding Train 920 at Stoughton, but only three boarding Train 922 there. Another 13 boarded before Back Bay, including one at Canton Center. If Train 922 left Stoughton at 6:09 it would serve stations from Canton Junction north between the times of Providence Trains 820

and 822 instead of after Train 822. It is unclear whether or not this would result in a net increase in ridership compared with the present schedule.

No other outbound trains currently arrive at Stoughton in time for the equipment to turn for additional inbound P.M. peak service. If Train 977 were extended from Canton Center to Stoughton, Train 978 would not be able to return to Boston early enough for the equipment to make its next scheduled departure. If Train 879, which terminates at Canton Junction at 4:44, were extended to Stoughton, it could still return to Boston as Train 880 in time for the equipment make its next scheduled outbound departure. The schedule would have to be coordinated with that of outbound Stoughton Train 917. If Train 880 left Stoughton at 5:06 and skipped Canton Center, Train 917 would have to be held at Canton Junction for six minutes. If the schedule of Train 917 was unchanged, Train 880 could not leave Stoughton until 5:20. Three counts on Train 880 in Spring 2000 showed boardings ranging from 12 to 14 at Canton Junction and from 25 to 56 at Route 128. It is unclear how a departure made later by 14 to 30 minutes would affect these boardings.

Prior to December 2000, Train 880 was scheduled to leave Canton Junction at 5:09, make intermediate stops at Route 128 and Back Bay, and arrive at South Station at 5:32. In December 2000, departure time from Canton Junction was moved up to 5:00, the train was re-routed via the Dorchester Branch eliminating the Back Bay stop, and arrival time at South Station became 5:23. These changes were made to avoid a scheduling conflict with a new outbound Amtrak Acela Express train that began running then. Because of the number of outbound commuter trains departing at around the same time, the Acela runs between South Station and Readville or even further south on Track 2, which is usually used only by inbound trains. Further analysis would be needed to determine how much flexibility there now is in scheduling Train 880. If still feasible, the annual operating cost increase resulting from extending Trains 879 and 880 from Canton Junction to Stoughton would be about \$95,000.

Counts on several days in Spring 2000 showed Back Bay alightings from Train 880 ranging from 23 to 42. On some days, this exceeded the number alighting at South Station, excluding passengers who boarded at Back Bay. The elimination of the Back Bay stop by Train 880 would now force passengers with final destinations around Back Bay either to take other inbound trains or to transfer to outbound trains at South Station.

A count on the middle of the three outbound A.M. peak Stoughton trains found only two passengers alighting at Stoughton and one at Canton Center. Alighting counts were not done for the other two trains at these stations, but all three trains left Boston with similar total loads. The low volume of A.M. peak reverse commuting may have been partly a result of the limited choice of inbound return times.

Feasibility of Increasing Inbound P.M. Peak Service at South Attleboro and Providence

The present two inbound P.M. peak trains serving Providence and South Attleboro are Trains 820 and 822, leaving Providence at 5:15 and 5:55. Train 820 has been running from Providence only since the Summer of 2000, when it replaced a South Attleboro train. The equipment for Trains 820 and 822 turns from the first two outbound P.M. peak trains arriving in Providence at 4:51 and 5:45. The third outbound train (Train 817) is due at Providence at 6:08, and could theoretically start a northbound trip at 6:18, stopping at South Attleboro at 6:26. Currently the equipment runs in non-revenue service to the East Junction layover facility in Attleboro, but it is supposed to be reassigned to a new yard to be built closer to Providence.

If the equipment from Train 817 made an inbound P.M. peak trip to Boston, another outbound trip would also need to be added to position the train set for the start of the next service day. The added cost of a round trip would be about \$1,030,000 a year. Alternatively, if a new equipment set were acquired for an additional outbound A.M. peak train to Providence, and remained there all day, it could also be used for an inbound P.M. peak trip, with the equipment remaining in Boston overnight. The operating cost of the inbound trip alone would be about \$515,000 a year.

Schedules of any new commuter trains on this line would have to be coordinated with those of Amtrak intercity trains. The latter are still changing frequently as new high-speed express service is phased in, so it is difficult to predict what time slots would be available for commuter trains in future years.

Potential Use of Amtrak Intercity Trains for Commuting between Boston and Providence

In addition to MBTA commuter rail trains, several Amtrak intercity trains allow travel between Boston and Providence during peak hours. These trains are faster than the commuter trains, but also charge much higher fares. They are more likely to attract business or non-work travelers than daily commuters.

In the past, arrangements between the MBTA and Amtrak allowed for acceptance of MBTA tickets and passes on some Amtrak trains for travel between Boston and Providence. Amtrak was reimbursed in some way for these riders, but there was less disparity between commuter and intercity fares then. Such an arrangement now would reduce Amtrak revenue from passengers who would otherwise pay full intercity fares, but would add new revenue from passengers who would not ride trains at all. Subsidy payments to Amtrak for allowing commuters to use MBTA tickets to ride between Boston and Providence could be less costly than adding more commuter trains, as long as the number of commuters was not so great as to displace longer-distance Amtrak riders. More detailed information on present load factors on Amtrak trains between Boston and Providence would be needed to determine the feasibility of such a program.

Detailed Analysis - Middleborough/Lakeville Line

A.M. Peak Service

At present (Spring 2001) the Middleborough/Lakeville Line has four inbound A.M. peak trains. The first three of these use train sets that are kept overnight at the Middleborough layover facility and are making their first trips of the day. The fourth peak train uses a set that initially provides the first inbound A.M. peak trip on the Kingston Line, then goes to Middleborough as the first outbound A.M. peak train on that line. The equipment from the first inbound peak Middleborough train turns to become the first outbound Kingston train. The equipment from the third peak train turns to a Plymouth train, and that from the fourth train turns to an outbound Middleborough train that leaves after the end of the A.M. peak.

There is also one inbound Middleborough train due at South Station at 6:19, just before the start of the A.M. peak. The equipment from that currently turns to provide a new Mansfield round trip (Trains 831 and 832) on the Attleboro Line, even though the door controls are not full compatible with the operation on that line. The equipment from the second inbound A.M. peak Middleborough train remains in Boston, and would be available for outbound service on either Old Colony branch.

The first outbound A.M. peak Middleborough train (Train 003) leaves South Station at 6:45, using equipment that arrives on Kingston Train 032. Possible departure times for outbound trains are constrained by the long single-track segments on both Old Colony branches and on the shared line north of Braintree. In order to maintain existing inbound schedules without delays, the next available time for a new outbound train to leave South Station after Train 003 would be at about 7:35. Before completing its run, this train would have had to wait on passing tracks for inbound Middleborough trains 006, 008, and 010, and Kingston trains 036 and 038. The total running time from South Station to Middleborough/Lakeville would be at least 78 minutes, compared with 60 and 55 minutes for the two outbound A.M. peak trains now provided. The equipment from Kingston Train 034, due at South Station at 7:24, is currently idle after that until early afternoon, and would be available to use on a 7:35 Middleborough train.

The second inbound Middleborough peak train (Train 006) is due at South Station at 7:54. The train set could theoretically be ready for an outbound departure as early as 8:04, but departure would have to wait until after the arrival of Kingston Train 036 at 8:08 and Middleborough Train 008 at 8:16. The second outbound Middleborough train (Train 005) is scheduled to leave at 8:25, using the equipment from Train 036, so a new train with equipment from Train 006 would not be useful until later. Track capacity at South Station limits the amount of time that train sets can be held there during the A.M. peak, however. Disregarding that constraint, assuming that a new trip should be separated by at least 30 minutes from Train 005 to offer flexibility in travel times, the next new trip should not leave South Station until 8:55. There is already an outbound Plymouth train (Train 061) leaving at 8:50, and signal spacing would not allow a departure after it before 8:55. Departure would also have to be delayed until the

approach of inbound Kingston Train 010, due at 9:02. With a 9:02 departure, the furthest station that could be reached before 9:30 would be Holbrook/Randolph. at about 9:28. Therefore, a new trip using equipment from Train 006 would be much less useful for reverse commuting than one using equipment from Train 034.

Outbound A.M. peak ridership during the Spring 2000 counts was lower than usual because Bridgewater State College was on a break, so Fall 1999 counts are more representative. They show 31 riders on board Train 003 and 56 on board Train 005 after Braintree. A new train leaving between these two would be expected to have ridership somewhere between these totals if it offered similar travel times, but for reasons discussed above, it would be much slower. Some of the riders on the new train would shift from the others to get arrival time closer to their needs despite the longer on-train times. The added operating cost of one A.M. peak round trip would be about \$845,000 a year.

P.M. Peak Service

Inbound Middleborough Trains 018, 020, and 022 all serve some stations in the P.M. peak. Train 018 leaves Middleborough/Lakeville at 3:26, just before the start of the P.M. peak as defined for this study, but makes all other stops after 3:30. Train 022 reaches Montello at 6:27, but makes all subsequent stops after 6:30.

The only CTPS counts of boardings and alightings at individual Old Colony stations south of Braintree were done in October 1998. They showed seven passengers alighting at Middleborough from the two outbound A.M. peak trains. Total ridership on these trains had doubled by Fall 1999. A proportional share of the growth would have raised Middleborough alightings to 14. The Fall 1998 counts also showed Middleborough boardings of nine, nine, and five on Trains 018, 020, and 022. Overall ridership on these trains increased 35% by Fall 1999. A proportional share of the growth would have raised Middleborough boardings to 31. The 1998 survey found only two work-to-home trips boarding at Middleborough/Lakeville Station, both on Train 022 and their final destination was beyond Boston. These results indicate that having Train 018 serve Middleborough slightly after 3:30 instead of slightly before would have little impact on ridership.

Stations at which Train 022 stops after 6:30 are Holbrook/Randolph at 6:32, Braintree at 6:42, and Quincy Center at 6:48. Train 018 stops at Braintree but Train 020 does not. Three inbound Plymouth/Kingston Line trains also stop there in the P.M. peak, so the two lines together provide four trips. The Spring 2000 and Fall 1999 counts showed no passengers boarding Train 022 at Quincy Center. Train 020 had only one Quincy boarding in both counts. Train 018 had one Quincy boarding in Spring 2000 and four in Fall 1999. No inbound P.M. peak Plymouth/Kingston trains stop at Quincy Center. Much more frequent service to Boston from both Braintree and Quincy Center is provided by the Red Line. In view of this and the low ridership on present trains, there is no need for a third inbound P.M. peak Old Colony train serving Quincy Center.

The departure time of Train 022 from Randolph is only two minutes after the cut-off time used in this study for P.M. peak service. The Fall 1998 counts at Holbrook / Randolph showed only two alightings there from the two outbound A.M. peak trains and seven boardings on Trains 018, 020, and 022, including two on Train 022. Proportional shares of ridership growth on these trains would not have altered these figures noticeably. The 1998 survey showed only two work-to-home trips to Boston boarding at Holbrook / Randolph. These results indicate that there is no need to provide another inbound P.M. peak train at this station.

Detailed Analysis - Plymouth/Kingston Line

The outer end of the line is divided into two branches, with one terminating at Kingston and the other at Plymouth. The two branches divide between Halifax and Kingston, so trains from both branches can serve all of the same stations other than the two terminals.

A.M. Peak Service

At present (Spring 2001) the Plymouth / Kingston Line has five inbound A.M. peak trains. The first four of these use train sets that are kept overnight at the Kingston layover facility and are making their first trips of the day. The fifth inbound train (Train 040) uses a set that first makes the first inbound peak trip from Middleborough (Train 004), and then makes the first outbound Kingston trip (Train 033). The equipment from the second inbound train (Train 034) remains in Boston, and would be available for outbound service on either Old Colony branch. (A possible use of this set on the Middleborough / Lakeville Line is discussed above.) The equipment from the third inbound train (Train 036) is used on the second outbound trip on the Middleborough / Lakeville Line (Train 005). The equipment sets from the fourth and fifth peak trains (Trains 038 and 040) are used on the first two outbound trips after the A.M. peak.

At present the first outbound train leaves South Station at 7:10 and goes to Kingston. The second train leaves at 8:50 and goes to Plymouth, but the last station it gets to before 9:30 is Hanson. Between these departures, arriving Old Colony trains from which the equipment remains in Boston are Kingston Train 034 at 7:24 and Middleborough Train 006 at 7:54. Each of these could theoretically be ready to do an outbound trip about 10 minutes after inbound arrival.

As discussed in the Middleborough / Lakeville Line section above, with present schedules of inbound trains, the earliest available time for an outbound train on either Old Colony branch that is not already taken would be one at around 7:35. If such a train were to be run it would be slightly more productive to send it to the Middleborough / Lakeville Line than to the Plymouth / Kingston Line, because the latter serves fewer potential reverse commuting destinations. The next available outbound time slot would be at about 8:14. A train leaving then would arrive at Braintree at about 8:31, and would arrive at either Kingston or Plymouth at about 9:10.

The Spring 2000 counts for the first outbound Kingston train (Train 033) showed 26 riders boarding at South Station and traveling further than Braintree. This was only slightly more than the 24 observed in Fall 1999. The first outbound Plymouth train (Train 061) had only 11 South Station boardings, compared with 21 in Fall 1999. The 1999 count showed no alightings at Quincy Center or Braintree, but alightings there were not counted in 2000. The 1998 survey showed that travel on Plymouth trains consists largely of recreational trips to Plymouth, and large day-to-day ridership variations would be consistent with that. A new outbound trip between Trains 033 and 061 could also be expected to carry no more than about 25 riders, and some of these would be diverted from other trains. The added operating cost of one A.M. peak round trip would be about \$840,000 a year.

It would be feasible at no added operating cost to change the outer terminal of outbound Train 033 from Kingston to Plymouth if the demand justified it. The Fall 1998 counts found 10 riders alighting from Train 033 at Kingston and 113 boarding Train 040 (which uses the same equipment) there. CTPS has not done more recent counts at Kingston. Spring 2000 counts at South Station and Braintree showed a net increase of six riders going from Boston to all points South of Braintree on Train 033. Total South Station alightings from Train 040 decreased from 262 in Fall 1998 to 237 in Spring 2000.

If the starting point for Train 040 was changed to Plymouth, many of the passengers who now board at Kingston could board at Plymouth with little or no inconvenience. The 1998 survey found that the most common single origin location of Train 040 boardings at Kingston was Plymouth, with 45 (39.7%). Another 28 (25%) had origins south or west of Plymouth and would have passed through Plymouth on the way to Kingston. The only passengers who would have had to travel further to reach Plymouth Station than Kingston Station were 12 from Kingston, 27 from Duxbury, and two from Marshfield. Many of the riders from those towns now board at Halifax or Hanson instead of Kingston, and Halifax has some unused parking capacity.

Diversions of riders from Kingston to Plymouth would provide some relief for constrained parking at Kingston. CTPS observations in April 2000 found all parking at Kingston full at midday, but 88 of 92 spaces at Plymouth vacant. Of the 72 riders who boarded Train 40 at Kingston and started from Plymouth or points further south or west, 57 (79%) drove and parked at the station. Of the rest, 10 were dropped off, two rode as passengers in cars that were parked at the station, and four used bus connections that they could have taken to Plymouth Station instead. Of the 41 from Kingston, Duxbury or Marshfield, 37 drove and parked at Kingston Station, two rode as passengers in cars that were parked at the station, and two were dropped off. Therefore, anyone who went to Kingston to board Train 040 would also have had a means of access to Plymouth or another station.

A major disadvantage for park-and-ride passengers boarding at Plymouth instead of Kingston would be the much less frequent outbound return service. At present, Train 040 is due at South Station at 9:28 A.M., which is early enough for some work trips, but the last outbound Plymouth train all day leaves South Station at 3:00 P.M. Therefore, for

most passengers, diverting Trains 033 and 040 from Kingston to Plymouth would only be an improvement if outbound P.M. peak service to Plymouth were also implemented.

P.M. Peak Service

In the P.M. peak, inbound Train 048 originates at Kingston and also stops at Halifax but then runs non-stop to Braintree. Train 066 originates at Plymouth and serves all stations except, Kingston, Quincy Center, and JFK/UMass. Train 052 originates at Kingston and stops at all stations except Plymouth, Quincy Center, and JFK/UMass, but it gets to all stations north of Kingston after 6:30. Train 096, which has been running only since April 30, 2001, originates at Abington and also stops at South Weymouth and Braintree.

The reason for having Train 048 run non-stop north of Halifax is unclear. The scheduled time from departing there to departing Braintree is only three minutes less than the scheduled times for trains stopping at four intermediate stations, and no outbound trains are met south of Braintree. One outbound train is passed between Braintree and South Station, but it should be possible to maintain the present schedule north of Braintree while stopping at more stations south of there.

Four outbound P.M. peak trains go to Kingston and one terminates at Abington. The train sets from the first and third Kingston trips (Train 043 and Train 047) proceed to the Kingston layover facility and are not used again until the following day. Equipment from the second Kingston trip (Train 045) is used on the last inbound peak trip (Train 052) which gets to all stations except Kingston after 6:30. The equipment from the outbound Abington trip (Train 095) returns from Abington as Train 096 after the minimum 10-minute allowance, and turns to provide the fourth outbound Kingston trip (Train 049). After Train 049, this set is used on the first inbound trip after the end of the P.M. peak. The set from Trains 043 could theoretically be used to operate additional inbound P.M. peak service, but Train 047 arrives too late for that.

Train 043 arrives at Kingston at 5:10, and could depart at 5:20 at the earliest. Because of schedules of outbound trains, departure would have to be closer to 5:30. Outbound Kingston Trains 045 and 049 would be passed between Kingston and Braintree, outbound Middleborough Train 019 at Braintree, and Kingston train 049 between Braintree and Boston. Delays for meeting outbound trains would result in a running time of at least 60 minutes from Kingston to Boston, or 10 minutes longer than that of Train 052. An additional outbound trip would need to be run to return the equipment to Kingston before the start of the next service day. Train 047 arrives at Kingston at 6:25. The equipment could be used at the earliest on a new train departing at 6:35, but this would be after the end of the P.M. peak.

In the Spring 2000 counts, Train 066, which then was due in Boston at 5:30, had 29 passengers who boarded south of Braintree. Train 048, which makes limited stops, had 13 Boston alightings. This train usually has no Braintree boardings. When last counted in Fall 1999, Train 052, then due in Boston at 7:25 had 13 Boston alightings from south of

Braintree. A new train arriving in Boston at about 6:30 would be mid-way between the old times of Trains 066 and 052. Ridership would probably not exceed that on Train 066, and some of the riders would be diverted from other trains. In conjunction with the addition of Train 096 from Abington, the scheduled Boston arrival times of Trains 066 and 052 were changed to 4:47 and 7:30. At this time it is too soon to evaluate ridership on Train 096. It may have diverted some riders from Abington or South Weymouth who find the new time of Train 066 too early but that of Train 052 too late. A new train arriving at 6:30 would be between Trains 096 and 052 at Abington and Weymouth. At the outer stations it would still be between Trains 066 and 052, but closer to the latter than the former.

The added operating cost of one P.M. peak round trip would be about \$840,000 a year. Adding stops by train 048 might attract about 20 more riders to that train.

Old Colony Service to JFK/UMass Station

A commuter rail platform for the Old Colony Lines adjacent to the JFK/UMass Red Line station opened on April 30, 2001. This station is in Dorchester, 2.5 miles from South Station. This is the same as the distance from South Station to Yawkey on the Framingham/Worcester Line, and slightly longer than the distance from South Station to Ruggles on the Attleboro/Stoughton, Franklin, and Needham Lines (2.2 miles).

The initial weekday schedule at JFK/UMass included three Middleborough/Lakeville Line and four Plymouth/Kingston Line trains each way. On the Middleborough/Lakeville Line, all three inbound trips were in the A.M. peak. Two of the outbound trips were in the P.M. peak. The third was a mid-evening trip. Inbound service on the Plymouth/Kingston Line was provided by three A.M. peak and one mid-morning trains. Outbound service included one afternoon, two P.M. peak and two late evening trips. This schedule provides an opportunity to test demand at a variety of times, but at this writing it is too soon to evaluate ridership.

The JFK/UMass station is expected to be used mostly for travel from homes served by outlying Old Colony stations to work and school destinations served by JFK/UMass station. Shuttle bus service between the station and UMass Boston is provided by the university. Connections are also provided by MBTA bus Routes 8 and 16.

The present schedules would also allow peak-period commuting from homes around JFK/UMass to downtown Boston work locations. Reverse commuting between downtown Boston and JFK/UMass would not be possible. It is unlikely that such service would attract many riders even if it were available. Scheduled Old Colony times between JFK/UMass and South Station are nine to 10 minutes inbound and six minutes outbound. The scheduled time on the Red Line is seven minutes each way. The Red Line offers much more frequent service, and direct service to more stations. JFK/UMass is in commuter rail fare Zone 1A. The one-way fare to South Station is \$1.00, the same as the Red Line fare. The same monthly passes are required for both

services. A 12-ride ticket, valid for Old Colony service but not on the Red Line, lowers the cost per ride to 92 cents.

If Old Colony service at JFK/UMass included outbound A.M. peak and inbound P.M. peak trains, they could also be used for reverse-commuting between homes near JFK/UMass and work locations near outlying Old Colony stations. Currently, such trips would require taking the Red Line from JFK/UMass to either Quincy Center or Braintree to transfer to Old Colony trains. Fall 1999 counts showed 69 passengers boarding the two outbound A.M. peak Middleborough/Lakeville trains at South Station and another 18 at Quincy Center, all for destinations south of Braintree. The two outbound A.M. peak Plymouth/Kingston Line trains had 36 boardings at South Station, four at Quincy Center, and eight at Braintree for destinations south of Braintree. If trains stopped at JFK/UMass, boardings there would be expected to be more similar to those at Quincy Center and Braintree combined than to those at South Station. For comparison, only three to nine passengers boarded each of the three outbound A.M. peak trains stopping at Ruggles in the Spring 2000 counts.

The JFK/UMass Old Colony platform is located within a single-track segment that extends from about one mile north to about 1.5 miles south of the station. Trains that now stop at JFK/UMass have had two to three minutes added to their former scheduled times to allow for acceleration, deceleration, and station dwell time. Adding stops at JFK/UMass by outbound A.M. peak or inbound P.M. peak trains would increase potential scheduling conflicts with other trains not only on the single-track segment running past the station but on several others further south.

5. POTENTIAL FOR FEEDER SERVICE CONNECTIONS BETWEEN COMMUTER RAIL LINES AND REVERSE COMMUTING DESTINATIONS ALONG ROUTE 128 AND I-495

Introduction

The legislation mandating the reverse commuting study requires that it include an analysis of "additional bus services and routes necessary to provide north and south connecting services between commuter rail stations located in municipalities along the state highway Route 128 and interstate highway route 495 corridor and the demand for such services."

For purposes of this chapter, this has been interpreted to mean an analysis of the potential for operating new bus or van routes connecting employment areas along either Route 128 or I-495 with commuter rail stations. These are both circumferential highways describing long arcs through suburbs north, west, and south of Boston. On both highways, the posted directions are north and south, but in many locations the actual compass directions are east and west.

For such a connecting bus or van route to exist at all, it is of course essential that there be roads leading from a station on a rail line to one or more areas along Route 128 or I-495 where Boston residents are employed or could find work. Beyond that basic consideration, success of such a route would depend on a number of factors including total travel time from home to work location, scheduled versus desired arrival time at work location, ease of access from residence to commuter rail station at the inner trip end, and trip expense.

In general, bus routes designed to allow passengers to transfer between two different commuter rail lines with stations on Route 128 or I-495 would be impractical, because a bus departing a station on one line shortly after arrival of a train would not be able to arrive at a station on another line close to the departure time of a train on that line. Passengers starting from Boston can board any line in the commuter rail system there. Very few passengers now make work trips entirely outside of Boston on any one commuter rail line, and most of them live within walking distance of their boarding stations. Most passengers who would have to drive to boarding stations could use the same vehicles to complete their entire trips in less time than if they took the trains. There is little reason to believe that significant numbers of suburban residents would make trips requiring train-bus-train connections.

In the discussion below, general issues are addressed first, followed by line-by-line analysis of potential routes. The overall finding is that there are few cases where the locations of rail lines, highways, and employment areas would allow for operation of attractive reverse commuting service involving rail-to-bus connections. Even in these locations, ridership would be very limited because of the many competing work location opportunities available to Boston residents.

Summary of Findings

There are relatively few locations where bus connections from commuter rail lines to destinations along Route 128 would be expected to attract enough riders to justify such service. These are from Anderson / Woburn Station on the Lowell line to employment centers in Woburn, from Waltham Station on the Fitchburg Line to industrial and office parks on both sides of Route 128 in Waltham, and from Route 128 Station on the Attleboro / Stoughton Line to employment areas in Westwood and Norwood. Some such service is already provided at Waltham, Route 128, and Woburn but has not attracted substantial numbers of riders.

In the case of Waltham, a van to one office park complex was carrying 20 to 25 riders each way per day as of November 2000, but it was not reported how many of these transferred to or from trains. Additional connections are now provided by a city-sponsored bus network that began operating at the end of December 2000. In the case of Route 128 Station, a minibus to multiple employment destinations was observed in December 2000 to be carrying a total of 55 riders transferring from five outbound trains.

The Anderson / Woburn Station opened on April 30, 2001. At the same time service to Mishawum Station in Woburn was discontinued except for three outbound A.M. peak and three inbound P.M. peak trips used by reverse commuters. A December 2000 count at Mishawum noted private connecting services being provided by two individual employers. They carried a total of 15 riders who transferred from four outbound A.M. peak trains.

Cities and towns along I-495 all employ much smaller numbers of Boston residents than those served by the Woburn, Waltham, or Route 128 stations, and also draw much smaller percentages of their total labor forces from Boston. The best ridership potential for connecting service in the I-495 corridor appears to be from the new Southborough Station being built on the Framingham / Worcester Line to employment areas in Marlborough. Overall travel times for such service would, however, be longer than those for reverse commuter bus route from Boston that was carrying only one rider a day in April 2000 and was discontinued in April 2001. Some modifications to existing bus routes operated by the Lowell and Merrimack Valley Regional Transit Authorities in communities on the Newburyport, Haverhill / Reading, and Lowell commuter rail lines could improve connections for reverse commuters. There does not appear to be sufficient demand to justify institution of new dedicated feeder routes in these areas.

Factors Affecting Design of Feeder Service Connections

Proximity of Rail Stations and Work Locations to Highways

Feeder bus services along Route 128 or I-495 would have to be run from commuter rail stations at or near interchanges on these highways. At present, all MBTA commuter rail lines except the Fairmount line extend beyond Route 128, but only the Lowell, Franklin, and Attleboro / Stoughton lines currently have stations directly at the locations where

they intersect that highway. The two Old Colony lines do not intersect Route 128, but cross a segment of state Route 3 that was once part of Route 128, so they are included in the discussion below.

The Haverhill / Reading, Lowell, Fitchburg, Framingham / Worcester, Franklin, Attleboro / Stoughton, and Middleborough / Lakeville lines all extend beyond I-495. Of these, however, only the Franklin and Middleborough / Lakeville lines have stations at interchanges on that highway. (The Littleton / Rte 495 Station on the Fitchburg Line is close to the point where I-495 crosses the rail line, but to drive between the station and highway currently requires traversing about two miles of narrow local roads.)

Route 128 and I-495 are both limited-access highways, and interchanges along each are often several miles apart. Connections between rail stations and most businesses and industries located along the corridors of these highways would therefore involve use of frontage roads and local circulator roads within office or industrial parks. Except in cases where an individual work site would generate enough ridership to support a dedicated feeder route, the further a work site was from a rail station the more delays workers going there by van or bus would be subjected to because of intermediate stops.

Train Frequency

In most cases, the most frequent feasible reverse commuting service that could be offered to a station on Route 128 or I-495 would have intervals of 20 to 30 minutes between trains. The specific train arrival times that can be offered at an individual station are constrained by factors such as track layout, schedules of trains in the opposite direction, and schedules of other trains with which rolling stock is shared. Even if there were complete flexibility in scheduling arrival times, any given time would be convenient for only a small proportion of potential riders. Work shifts do not start at the same time at every work location that would be served by a given station, and the travel times from the station to different work locations would vary as well. Most workers without flexible starting and ending times for their work shifts would need to use trips that would bring them to their work sites earlier and take them away later than their preferred times.

Rail Access at Inner Trip End

At the inner trip end, the largest numbers of Boston residents who are either currently employed in municipalities along the Route 128 or I-495 corridors or who might seek employment in such locations do not live within walking distance of a station on the commuter rail line that they would need to use to travel to work. Therefore, most of them would have to start their trips using some combination of local bus and rapid transit service. The greater the number of feeder services involved in the trip, the more difficult it would be to arrange for arrival at the commuter rail boarding station close to but before the scheduled departure time of the train that would need to be ridden to get to work on time.

Fares

The present commuter rail fare structure uses a zone system based roughly on distance traveled. Routes 128 and I-495 are both circumferential highways, running around Boston on all sides except to the east. Neither highway intersects all rail lines at uniform distances from downtown Boston, so fares would not be the same to all destinations along either highway.

The stations nearest Route 128 are in fare zones ranging from Zone 2 to Zone 7. For a daily commuter, the least costly fare alternative would be to use a monthly pass. Used for an average of 21 round trips a month, this would result in an average fare per trip ranging from \$2.24 at a Zone 2 station to \$3.64 at a Zone 7 station. A monthly pass would also allow free transfers to and from other MBTA services. Fares on Route 128 or I-495 feeder services would be additional unless these services were run directly by the MBTA or were funded by employers. For infrequent riders, the most costly fare option would be use of single-ride tickets. Fares would range from \$2.75 one-way in Zone 2 to \$4.50 in Zone 7, and fares on connecting MBTA services would have to be paid in addition to these. Informal surveys of some employers along Route 128 have revealed that even Zone 2 fares are believed to be a deterrent to attracting reverse commuters from Boston.

Commuter rail stations nearest to I-495 are all in fare zones 6, 7, or 8. Average fares using monthly passes would range from \$3.45 in Zone 6 to \$3.79 in Zone 8. Single-ride fares would range from \$4.25 to \$5.00.

Employment Attractions For Boston Workers

General Considerations

Commuter rail service either alone or in combination with connecting bus or van service could be expected to carry only some sub-segment of the total market for reverse commuting trips from Boston to communities along Route 128 or I-495. According to 1990 Census Journey-to-Work tabulations (the most recent for which results are currently available), 79% of Boston residents who commuted to work anywhere other than Boston either drove alone or rode in carpools. Only 17% used public transportation, with about half of these using buses. In most cases, alternatives including commuter rail would be unable to match the door-to-door travel times of private auto transportation and would provide less convenient work arrival and departure times. Therefore, few commuters with the option of using private auto transportation would be diverted to new rail/bus services. The number of workers deterred from taking jobs along Route 128 or I-495 only by lack of auto transportation would be small in comparison with the number who already drive. Therefore, an examination of existing reverse commuting volumes from Boston to Route 128 or I-495 is useful in analyzing the ridership potential of new reverse commuting services.

The number of Boston residents commuting to work in any given city or town depends on many factors, including among others the total number of jobs in those communities,

the nature of these jobs, and the attractiveness of these jobs for workers compared with other opportunities available to them. All other things being equal, workers are more likely to take jobs in locations closer to their homes than in locations further away.

Route 128 Corridor

Route 128 runs through a total of 21 cities and towns, and the former segments now included in I-93 and Route 3 add three more. Table 5-1 shows the number of Boston residents employed in each of these communities in the 1990 U.S. Census figures. It also shows percentage changes in total employment (but not employment of Boston residents alone) from 1990 to 1999 based on figures from the Massachusetts Division of Employment and Training (DET).

In the Census figures, communities along Route 128 provided employment for a total of 33,250 Boston residents. The city of Newton attracted by far the greatest number of workers from Boston of any Route 128 community, at 7,300. Route 128 enters Newton for only a short distance on the western border, however, and most of the jobs in the city are not near that highway. Some sections of Newton directly adjoin residential sections of Boston, and Newton was second of all Route 128 communities in total employment.

The other nine of the top ten Route 128 communities each employed between 1,000 and 5,000 Boston residents. (These were Waltham, Quincy, Dedham, Braintree, Needham, Wellesley, Woburn, Burlington and Canton.) Nine of the top ten employers of Boston residents also ranked in the top twelve for total employment. Dedham, which borders directly on West Roxbury and Hyde Park, ranked only fourteenth in total employment, but was fourth in total Boston workers among Route 128 communities. Burlington is the only one of the 10 that is not located on a rail line.

Only three towns on Route 128 employed fewer than 170 Boston workers each in 1990. These were Lynnfield (97), Manchester (34) and Wenham (18). These were among the most distant towns from Boston on Route 128, and they were also the lowest three in total employment.

When all work destinations of Boston residents outside of Boston and Cambridge are compared, Newton still ranks first, and five of the top ten Route 128 communities are in the top ten overall. Of the other five, all but Canton and Burlington are in the top 15.

In terms of importance to employers, Boston residents accounted for 7.5% of all workers employed in towns along Route 128. The importance in individual cities and towns ranged from a low of 1.2% in Beverly to a high of 17.9% in Dedham, with shares of over 10% in only five of the 21. Again, it should be noted that many of the jobs were not directly along Route 128 itself.

Table 5-1
Total Employment and Employment of Boston Residents in Cities and Towns on Route 128

City or Town	Total Employment 1990 Census	Employment Growth 1990-99 (Mass. DET)	Employment of Boston Residents 1990 census			% of Jobs Held by Boston Residents	% of all Boston Workers Employed	Estimated 1999 Boston Workers at Ave. Growth Rate
			Boston Proper	Boston Other	Total			
Newton	43,869	6.60%	898	6,402	7,300	16.64%	2.64%	7,782
Waltham	60,544	0.87%	591	4,390	4,981	8.23%	1.80%	5,025
Quincy	42,007	18.26%	401	3,970	4,371	10.41%	1.58%	5,169
Dedham	13,962	6.80%	15	2,489	2,504	17.93%	0.91%	2,674
Braintree	28,811	2.88%	199	2,040	2,239	7.77%	0.81%	2,303
Needham	18,106	-3.63%	131	1,644	1,775	9.80%	0.64%	1,711
Wellesley	18,130	5.77%	94	1,321	1,415	7.80%	0.51%	1,497
Woburn	29,018	9.71%	262	1,050	1,312	4.52%	0.47%	1,439
Burlington	29,267	15.90%	268	917	1,185	4.05%	0.43%	1,373
Canton	16,500	4.31%	86	948	1,034	6.27%	0.37%	1,079
Lexington	22,499	10.39%	138	723	861	3.83%	0.31%	950
Westwood	8,170	6.53%	69	776	845	10.34%	0.31%	900
Randolph	9,740	-2.43%	45	651	696	7.15%	0.25%	679
Milton	5,714	18.47%	42	649	691	12.09%	0.25%	819
Peabody	20,711	24.36%	72	312	384	1.85%	0.14%	478
Wakefield	10,914	29.55%	51	266	317	2.90%	0.11%	411
Danvers	19,594	-3.61%	99	212	311	1.59%	0.11%	300
Reading	7,143	18.55%	25	246	271	3.79%	0.10%	321
Weston	2,928	-0.31%	62	170	232	7.92%	0.08%	231
Beverly	16,383	14.68%	61	129	190	1.16%	0.07%	218
Gloucester	12,787	4.68%	0	174	174	1.36%	0.06%	182
Lynnfield	3,085	32.99%	21	76	97	3.14%	0.04%	129
Manchester	1,688	23.30%	0	34	34	2.01%	0.01%	42
Wenham	1,441	79.58%	18	0	18	1.25%	0.01%	32
Total	443,011	8.65%	3,648	29,589	33,237	7.50%	12.04%	35,744

I-495 Corridor

Route 1-495 runs through a total of 35 cities and towns. Table 5-2 shows the number of Boston residents employed in each of these communities in the 1990 Census Journey-to-Work tabulations, and percentage changes in total employment from 1990 to 1999 based on DET figures.

In the Census figures, communities along I-495 provided employment for a total of 3,358 Boston residents, or about one tenth the number employed in Route 128 communities. The city of Marlborough attracted by far the greatest number of workers from Boston of any I-495 community, at 556, and was second only to Lowell in total employment. Marlborough has some of the best highway access from Boston of any point along I-495, via the Mass. Turnpike to I-495 at Westborough. Ranking all Route 128 and I-495 communities together, Marlborough would have placed fifteenth in total employment of Boston residents in 1990. Many of the Marlborough jobs were not directly along Route I-495 itself.

Of the other 34 cities and towns along I-495, only four employed more than 170 Boston residents each in 1990. These were Lowell (298), Andover (287), Westborough (223), and Chelmsford (171). Only seven others employed over 100 Boston residents, with totals for the remainder ranging from zero to 99.

Nine of the top ten I-495 employers of Boston residents also ranked in the top twelve for total employment in that corridor. Hopkinton, which ranked only 25th in total employment in 1990 was ninth in total employment of Boston residents. This result was largely attributable to highway access similar to that of Marlborough. Nevertheless, Hopkinton employed only 140 Boston residents, or one fourth as many as Marlborough.

Only four of the top ten I-495 corridor employers of Boston residents (Lowell, Andover, Mansfield and Lawrence) currently have direct commuter rail service. Westborough will soon have a station on the Framingham / Worcester Line, and Hopkinton will be served by a new station just over the town line in Southborough. Taunton would be served by a New Bedford / Fall River extension, and Chelmsford could have a station on a Nashua extension of the Lowell Line. Marlborough would be served by an I-290 / Northborough branch of the Framingham / Worcester line. Tewksbury is on a rail freight line, but there are no plans to operate passenger service on it.

Putting I-495 work trips in perspective, when all work destinations of Boston residents outside of Boston and Cambridge are compared, Marlborough ranks only 32nd, and Lowell ranks only 45th in the 1990 Census figures. In terms of importance to employers, Boston residents accounted for 1.0% of all workers employed in towns along I-495. The importance in individual cities and towns ranged 0.0% in Salisbury and Merrimac to a high of 3.1% in Hopkinton, with shares of over 2.0% in only four of the 35. Again, it should be noted that many of the jobs were not directly along Route I-495 itself.

Table 5-2
Total Employment and Employment of Boston Residents in Cities and Towns on Route I-495

City or Town	Total Employment 1990 Census	Employment Growth 1990-99 (Mass. DET)	Employment of Boston Residents 1990 census			% of Jobs Held by Boston Residents	% of all Boston Workers Employed	Estimated 1999 Boston Workers at Ave. Growth Rate
			Boston Proper	Boston Other	Total			
Marlborough	25,364	31.02%	144	412	556	2.19%	0.20%	728
Lowell	36,718	-16.36%	66	232	298	0.81%	0.11%	249
Andover	23,019	27.65%	58	229	287	1.25%	0.10%	366
Westborough	15,528	22.99%	83	140	223	1.44%	0.08%	274
Chelmsford	14,526	36.93%	34	137	171	1.18%	0.06%	234
Tewksbury	14,344	82.74%	34	129	163	1.14%	0.06%	298
Taunton	18,355	15.73%	0	145	145	0.79%	0.05%	168
Mansfield	7,957	35.33%	0	143	143	1.80%	0.05%	194
Hopkinton	4,461	130.74%	18	122	140	3.14%	0.05%	323
Lawrence	20,954	-2.63%	45	94	139	0.66%	0.05%	135
Foxborough	7,032	8.48%	29	101	130	1.85%	0.05%	141
Hudson	9,040	9.61%	18	103	121	1.34%	0.04%	133
Littleton	5,972	9.32%	28	71	99	1.66%	0.04%	108
Franklin	7,712	61.77%	0	96	96	1.24%	0.03%	155
Milford	11,459	15.37%	0	90	90	0.79%	0.03%	104
Wrentham	3,839	7.47%	9	78	87	2.27%	0.03%	94
Southborough	4,623	36.12%	0	67	67	1.45%	0.02%	91
Methuen	9,789	-3.23%	9	45	54	0.55%	0.02%	52
Westford	5,026	89.18%	0	43	43	0.86%	0.02%	81
Newburyport	7,567	23.75%	12	30	42	0.56%	0.02%	52
Harvard	5,248	4.78%	0	40	40	0.76%	0.01%	42
Boxborough	2,436	-5.07%	20	19	39	1.60%	0.01%	37
Haverhill	14,628	8.76%	11	19	30	0.21%	0.01%	33
Bourne	6,272	15.39%	5	20	25	0.40%	0.01%	29
Amesbury	4,013	4.82%	0	23	23	0.57%	0.01%	24
Lakeville	2,937	39.12%	8	12	20	0.68%	0.01%	28
Norton	4,516	44.54%	0	18	18	0.40%	0.01%	26
Bellingham	2,539	59.65%	0	17	17	0.67%	0.01%	27
Rochester	785	59.19%	7	9	16	2.04%	0.01%	25
Middleborough	6,692	14.37%	8	5	13	0.19%	0.00%	15
Raynham	4,042	50.85%	4	7	11	0.27%	0.00%	17
Wareham	6,019	14.23%	7	0	7	0.12%	0.00%	8
Bolton town	1,309	54.25%	0	5	5	0.38%	0.00%	8
Salisbury	1,654	35.09%	0	0	0	0.00%	0.00%	0
Merrimac	951	34.12%	0	0	0	0.00%	0.00%	0
Total	317,326	20.03%	657	2,701	3,358	1.06%	1.22%	4,300

Estimated Change in Attraction of Boston Workers from 1990 to 1999

If employment of Boston residents in each city and town on Route 128 grew at the same rate as total employment in that community between 1990 and 1999, the rank order of some would have changed slightly, but the top ten would have remained the same. The top 10 would still have been the only ones with more than 1,000 Boston workers each.

If employment of Boston residents in each city and town on I-495 grew at the same rate as total employment in that community between 1990 and 1999, there would have been only one change in the group included in the top 10, although the order would have changed somewhat. Lawrence, which had a net decrease in total jobs, would have dropped from tenth to twelfth place. Franklin, which had the seventh-largest absolute gain in jobs would have risen from fourteenth place to tenth in total Boston employment. Of the towns employing fewer than 100 Boston residents in 1990, only Franklin, Littleton, and Milford would have had over 100 each in 1999, with 155, 108, and 104.

It is more probable that employment of Boston residents along Route 128 and I-495 grew at a slower rate than total employment in these corridors than at a faster rate. Between 1990 and 1999, the total number of Boston residents employed anywhere declined by 1,240, or 0.4%. In the same span, total jobs within the city of Boston increased by 37,156 (6.9%), jobs in Route 128 cities and towns grew by 39,381 (8.7%) and jobs in I-495 cities and towns grew by 64,407 (20.0%). Transportation between Boston and most points along Route 128 or I-495 did not improve significantly in that time. With a stable work force and increased employment opportunities close to home, there would be limited incentive for Boston workers to switch to jobs in more distant locations. This topic is discussed in greater detail in appendix B.

Line-By-Line Analysis of Route 128 Connections

Newburyport/Rockport Line

The Newburyport / Rockport Line has two branches, both of which intersect Route 128, but neither of which has a station directly at the crossing location. These branches are discussed separately below, because they serve different groups of towns.

Rockport Line

This line (officially called the Gloucester Branch) crosses Route 128 in Gloucester near the Blackburn Circle rotary (Exit 10). The rail line and the highway parallel each other, mostly at distances of one to two miles, between Gloucester and Beverly. Connecting bus or van service between most of the areas served by the highway and the nearest rail stations would not require use of Route 128 at all. For reasons detailed below, there is little potential for such routes to serve reverse commuting trips.

Route 128 Exit 10 is about one half mile by rail outbound from Gloucester Station. The rotary there serves an industrial park, but is otherwise inaccessible except via Route 128 itself. The Cape Ann Transportation Authority (CATA) operates a route from

downtown Gloucester to Blackburn Circle, but the stop nearest the railroad station is about one half mile away in the opposite direction from the Circle. There is no safe pedestrian route from the railroad station all the way to the Blackburn Industrial Park. It is possible to access the Blackburn bus route by walking downtown from the station or by taking another CATA route that links the station with the downtown stop. At present, however, the earliest possible Boston connection arrives at the industrial park at 9:45 A.M., and requires 64 minutes for a passenger to get there after arriving at the station by train. In the past, there was a 9:10 a.m. arrival with a 29-minute elapsed time from the station, but it apparently attracted too few Boston riders to justify retaining it.

Route 128 ends at Main Street in Gloucester, at Exit 9, the next interchange east of Blackburn Circle. Several CATA routes run through the vicinity of Exit 9, but do not provide direct connections from the commuter rail station. Route 128 itself would not be part of any route between the station and Exit 9.

West of Exit 10, Route 128 has four other interchanges in Gloucester. These are Exit 11 (Washington Street/Grant Circle), Exit 12 (Causeway Street), Exit 13 (Concord Street) and Exit 14 (Essex Street/Route 133). Exit 11 is on the edge of the business district, about one half mile from the railroad station, but the other three are in sparsely developed, mostly residential, areas. There is a CATA bus route running past the station and Exit 11, but it does not have a schedule suitable for reverse commuting.

Exits 12, 13, and 14 are all closer to West Gloucester Station than to Gloucester Station. A CATA bus route with a stop at West Gloucester Station runs past both Exit 13 and Exit 14, but it is not scheduled for reverse commuting. This bus route does not use Route 128. There is no direct bus service to Exit 12.

If additional bus service for reverse commuters were to be operated in Gloucester, it should be run either by CATA or by the employers to be served, but there appears to be little potential demand for such service. Gloucester is the most distant town from Boston on Route 128, and is as far away as most towns on I-495. At least partly because of this, Gloucester has historically had one of the lowest rates of attraction of reverse commuters from Boston of any community in the Route 128 corridor. The 1990 Census Journey-To-Work tabulations show no work trips to Gloucester from Boston Proper, and a total of only 174 from all of the rest of Boston. Only 10 of the latter trips were reportedly made by commuter rail. Total employment in Gloucester increased by only about 5% between 1990 and 1998, or a gain of 525 jobs.

The next town west of Gloucester on Route 128 is Manchester-by-the Sea. Most of the land along the highway in that town is sparsely developed, with little or no employment opportunity for Boston residents. There are two interchanges in the town. These are Exit 15 (School Street) and Exit 16 (Pine Street). Manchester Station is the nearest one to both of these, at about 1.4 and 1.6 miles. There is no bus service from the station to either of them, but also little or no potential employment around them. The 1990 Census found no work trips to Manchester from Boston Proper, and only 34 from

all of the rest of Boston, with none reportedly by rail. Between 1990 and 1999, total employment in Manchester increased by 23%, or 295 jobs.

Exit 17 is in the extreme eastern edge of Wenham, at Grapevine Road. Gordon College is located next to this interchange, but has no direct public transportation service. The Beverly Farms and Prides Crossing commuter rail stations are each about 2.5 miles away by local roads, but Prides Crossing has very limited service and no reverse commuting trains. The 1990 Census found 18 work trips to Wenham from Boston Proper, and none from the rest of Boston. Between 1990 and 1999, total employment in Wenham increased by 80%, or 525 jobs.

Beverly has several interchanges on Route 128, but of these only Exit 18 (Essex Street / Route 22) is closer to the Rockport Line than to the Newburyport Line. It is about one mile from Montserrat Station, in a sparsely developed, mostly residential, area.

Most employment areas on Route 128 in Beverly are closer to the Newburyport Line than to the Rockport Line. In conclusion, further analysis of feeder service connections along Route 128 from the Rockport Line is not warranted at this time.

Newburyport Line

This line crosses Route 128 in Beverly about one half mile by rail inbound from North Beverly Depot. MBTA bus Route 451 includes stops at this station and on Dodge Street near Route 128 Exit 20, where there is some employment. One outbound A.M. peak train makes a good connection with a Route 451 bus, and two inbound P.M. peak trains make fair connections with buses. A 1997 count found only two passengers all day alighting from southbound buses at the stops nearest Route 128, and a total of 26 all day alighting from northbound buses. There were eight boardings northbound and 29 southbound at the same stops.

A variation of Route 451 runs via Sohler Road and on Route 128 between Exits 20 and 19, but it does not include any stops near Exit 19. To connect with it, reverse commuters would have to transfer at Salem rather than North Beverly.

The 1993 commuter rail survey did not find any transfer activity between Route 451 and the rail line at any station. Because of this and the poor connections, it can be presumed that few if any of the passengers counted in 1997 transferred from trains. Even if the buses made good train connections the number of riders transferring would be expected to be much smaller than the number with local origins in Salem or Beverly. The 1990 Census found 61 work trips to Beverly from Boston Proper, and 129 from the rest of Boston. Between 1990 and 1999, total employment in Beverly increased by 15%, or 2,262 jobs.

The management of the Cummings Center office park at the former United Shoe Machinery (USM) complex in Beverly is interested in establishing some kind of reverse commuting service to that location. The site adjoins the Newburyport rail line 1.2 miles south of Route 128, and 0.7 miles north of Beverly Depot. As discussed in chapter 6, in

the past some commuter trains made a special stop for USM employees at that location, but it was used mostly for travel from North Shore points rather than from Boston. Present accessibility regulations would require a much more elaborate station facility than existed in the past. The MBTA is already planning to modify bus Route 451 to provide reverse commuting service to Cummings Center. The most direct routes for bus connections to Route 128 from the Newburyport commuter rail line would not run past Cummings Center, so service to that location is outside the scope of this chapter.

In conclusion, it does not appear that feeder bus connections from the Newburyport Line to segments of Route 128 in Beverly would have sufficient ridership potential to justify further analysis at this time. East of Exit 19, Route 128 runs through the area discussed above with respect to the Rockport Line. Exit 21 is in Beverly at Route 97, only a short distance west of Exit 20. Because of the location of the highway relative to the rail line, most points along Route 128 west of Exit 21 could be reached faster from Boston by a bus from Salem Station or further south than by one from North Beverly. Such connections are discussed in the next subsection.

Newburyport/Rockport Common Stations

Stations between Boston and Beverly Depot have the most frequent service on the Newburyport/Rockport Line, because they are served by trains going to points on both branches and by Beverly Depot short-turns. Greater frequency offers more possibilities for providing reverse commuting connections. These stations are also closer to points west of Beverly on Route 128 than are any of the stations north of Beverly Depot.

Exit 21 is the westernmost Route 128 interchange in Beverly. West of there, the highway runs through sections of Danvers, Peabody, Lynnfield, and Wakefield, crossing the Haverhill/Reading Line in the last of these. Exits 22, 23, and 24 are in Danvers, at Elliot Street, High Street, and Endicott Street. MBTA Route 458/468 from Salem Station to Danvers has several variations, all of which cross Route 128 in Danvers at either Exit 23 or Exit 24. The scheduled bus time from the station to either intersection is about 10 minutes. One outbound A.M. peak train has a scheduled nine-minute connection with a bus via Exit 23, but most trains have longer connecting times. A 1997 passenger count found almost no passengers boarding or alighting at stops in the immediate vicinity of Route 128, and fewer than 130 each way all day over the entire route.

The 1993 commuter rail survey found no work-to-home trips from Danvers to Boston via transfer from Route 458/468 and only two via other means of access. Even if the buses made good train connections, the number of riders transferring would be expected to be much smaller than the number with local origins. The 1990 Census found 99 work trips to Danvers from Boston Proper, and 212 from the rest of Boston. Between 1990 and 1999, total employment in Danvers decreased by 4%, or 804 jobs.

Exits 25 through 29 are all in Peabody, at Andover Street (Route 114), Lowell Street, Centennial Drive, and I-95. There is no Exit 27. West of Exit 29, Routes 128 and I-95 are the same, and the I-95 exit numbering system is used. Exit 29 is also I-95 Exit 45.

Bus Route 718 from Salem to the North Shore Mall in Peabody is operated for the MBTA by a private carrier under contract. It crosses Route 128 at Exit 25. The scheduled running time to that point from Salem Station is about 15 minutes. There is one outbound A.M. peak train with a connection of about 10 minutes to the bus. The largest concentration of employment in the vicinity of Exit 25 is in the mall, which is reached by the bus without the use of Route 128. Recent counts by individual stop are not available, but the route as a whole carries only about 50 riders each way per day.

MBTA bus Route 436 from Lynn to the North Shore Mall crosses Route 128 at Exit 26. It runs generally parallel with Route 128 east of the border of Lynnfield and Peabody, and is intended to serve the Centennial Park office complex in addition to the mall. This is a relatively slow route, with a scheduled running time of 28 minutes from Lynn Station to Centennial Park. If Route 718 were extended to Centennial Park, the running time to there from Salem Station would be about 24 minutes. Alternate service from Salem Station to the North Shore Mall and Centennial Park is provided by Peabody Transit, a peak-period van service funded by the city of Peabody and the Centennial Park developers. Scheduled times from Salem Station to Centennial Park range from 13 to 19 minutes, depending on the routing taken. The scheduled train time from Lynn to Salem is 10 minutes, so the fastest bus connection from Salem would save only five minutes of in-vehicle time compared with Route 436 from Lynn. At present three outbound A.M. peak trains connect with Route 436 buses at Lynn, but waiting times there range from 11 to 22 minutes. This is because the buses run on uniform 30-minute headways but the trains run on non-uniform headways. The fastest bus to Centennial Park from Salem has a scheduled two-minute connection from an outbound train.

Exit 28 is at the east end of the Centennial Park complex. Buses from Lynn could get there a few minutes faster by using Route 128 instead of the present bus Route 436 alignment on Lynnfield Street, but they would then have to double back along Lynnfield Street to reach most of the employment areas. There is no access to local streets at Exit 29/45. A Spring 2000 count found all-day combined totals of only 10 riders boarding Route 436 buses southbound and only 17 alighting northbound at all six stops serving the Centennial Park complex. The inner trip ends of these riders were not determined, but it would be expected that few if any of them transferred to or from trains at Lynn. A 1998 count at Salem Station found fewer than five riders alighting from the Peabody Transit van in the P.M. peak.

The 1990 Census found 72 work trips to Peabody from Boston Proper, and 312 from the rest of Boston. Between 1990 and 1999, total employment in Peabody increased by 24%, or 5,284 jobs, largely as the result of the establishment of Centennial Park.

Route 128 Exits 44 and 43 are in Lynnfield, at U.S. Route 1 and at Walnut Street. MBTA bus Route 436 passes about one half mile south of Exit 44 at Goodwins Circle. The scheduled bus time to that point from Lynn Station is 19 minutes. There is no significant employment in the vicinity of either Exit 44 or Goodwins Circle. A Spring 2000 count for Route 436 found only seven riders boarding southbound trips and only three alighting from northbound trips there all day. The 1990 Census found 21 work

trips to Lynnfield from Boston Proper, and 76 from the rest of Boston. Between 1990 and 1999, total employment in Lynnfield increased by 33%, or 1,101 jobs.

Most destinations along the Route 128 corridor west of Exit 44 could be reached faster by a bus from Wakefield Station on the Haverhill/Reading line than from any station on the Newburyport/Rockport Line. Scheduled outbound running times from North Station to Wakefield in the A.M. peak range from 22 to 25 minutes, compared with times of 19 to 23 minutes from North Station to Lynn, so Lynn has little train time advantage to offset longer bus times.

In conclusion, the low ridership on present bus routes serving points along Route 128 in Danvers, Peabody, and Lynnfield indicates that even with close train connections the number of reverse commuters from Boston who would use these routes would be negligible.

Haverhill/Reading Line

Connections to Wakefield and Points East

The Haverhill/Reading Line crosses Route 128 near Exit 39 at John Street in Wakefield, but does not have a station there. The nearest stations are Wakefield, about one mile further inbound, and Reading, about one mile further outbound. MBTA bus Route 137 from Malden Station to Reading stops at both Wakefield Station and Reading Station, and follows John Street between them. The scheduled running time between the two stations is about 11 minutes, with Route 128 being crossed at about the mid-point. Two outbound A.M. peak trips and one inbound P.M. peak trip make side diversions into an office park just inside Route 128, adding about two minutes to the running time. Train and bus schedules are not intentionally coordinated. The three outbound A.M. peak trains stopping at Wakefield have connecting times of 14, 6, and 4 minutes to outbound Route 137 buses. In no case would it be advantageous to transfer at Reading and double back. A Spring 1999 count found all-day totals of 12 passengers alighting from northbound buses at stops just south of Route 128 and another 10 on the north side. No more than three of these boarded at the stop at Wakefield Station. Returning southbound, there were no boardings at the stop on the north side of Route 128 and only one on the south side.

MBTA bus Route 136 from Malden Station to Reading diverges from Route 137 at Wakefield Square and bypasses Wakefield Station by about one third of a mile. It does run directly to Reading Station. The scheduled running time between Wakefield Square and Reading Station is 14 minutes. Route 128 is crossed on Lowell Street at Exit 40, slightly closer to Reading Station than to Wakefield Square. Schedules of Routes 136 and 137 are coordinated to provide alternating trips on the overlapping segments. Since Route 137 makes fair-to-good connections with outbound A.M. peak trains at Wakefield, Route 136 cannot also do so. Two of the three outbound trains have scheduled connections of two and four minutes with southbound Route 136 buses at Reading Station, however, so it is theoretically possible to travel from Boston to the exit 40 area of Route 128 by doubling back from Reading Station. Reading and Wakefield

are both in commuter rail fare Zone 2, and the bus fare to Route 128 from either station is the same, so there is no cost advantage from transferring at one station instead of the other. The train time from Boston to Reading is six minutes longer than that to Wakefield. There is much less employment potential around Exit 40 than around Exit 39. A Spring 1999 count showed no passengers alighting from southbound busses at the stops nearest to Route 128 on either side. Northbound, there were eight alightings all day at the nearest stop south of Route 128 and five at the nearest stop north, but as noted above, northbound trips would not have made good connections with trains for reverse commuting.

The 1990 Census found 51 work trips to Wakefield from Boston Proper, and 266 from the rest of Boston. Of these, only 18 were reportedly made by commuter rail. Between 1990 and 1999, total employment in Wakefield increased by 30%, or 3,222 jobs.

The next exit east of Exit 40 is Exit 41 at Main Street in the southwest corner of Lynnfield. Development between exits 40 and 41 is mostly residential, and much of the open land is unbuildable wetlands. East of Exit 41 Route 128 reenters Wakefield. A low-density industrial park runs along the north side of the highway for most of the way from Exit 41 to Exit 42 at Pleasure Island Road, but is accessible only from the Exit 42 end. At present there is no bus service to either Exit 41 or Exit 42.

Exit 43 is at Walnut Street in Lynnfield, in a predominantly residential area. Much of the nearby open land is occupied by a country club. There is no bus service to or near Exit 43, but there is little employment potential there. The next exit to the east is Exit 44 at U.S. Route 1 in Lynnfield. It is discussed above in the Newburyport/Rockport Line section.

Connections to Points West of Wakefield

To the west of Exit 39 in Wakefield, the next exit is Exit 38 at Main Street (state Route 28) on the border of Reading and Stoneham. Development in the area is mostly residential, but there is some low-density commercial development. At present there is no direct bus service to the Exit 38 area. MBTA bus Route 132 from Malden Station terminates at the Redstone Shopping Center in Stoneham, about three quarters of a mile to the south. Buses on this route also stop at the Wyoming Hill commuter rail station, but do not make good connections with outbound A.M. peak trains. The scheduled bus running time from Malden Station to Redstone is 25 minutes. There is insufficient slack in the schedule to allow for an extension of the route further north. If there were, the time from Malden Station to Exit 38 would be about 30 minutes. The bus running time from Wyoming Hill would be 13 minutes less. The commuter rail time from Malden Station to Wyoming Hill is only three minutes, but most Route 132 riders from Boston would transfer from the Orange Line rather than from Haverhill/Reading trains. (Spring 2000 counts showed no outbound alightings from commuter rail trains at Malden in the A.M. peak.) Commuter rail and Orange Line running times from North Station to Malden are about the same, but the Orange Line has the added advantage of direct service to more of the residential sections of Boston.

A bus from Wakefield Station could reach the Exit 38 employment area in about nine minutes. The train running time from Malden Station to Wakefield is 10 to 12 minutes, so excluding differences in waiting times for connections, travel between Malden and Exit 38 via Wakefield and a new bus route would be 9 to 11 minutes faster than taking an extended Route 132 from Malden. In-vehicle time via Wyoming Hill and an extended Route 132 would be about the same as that via Wakefield and a new bus route. Route 132 also connects with the Orange Line at Oak Grove. Transferring there instead of at Malden reduces net in-vehicle time by about six minutes, but this may be offset by a longer wait at Oak Grove.

Reading attracts fewer reverse commuters from Boston than Wakefield does. The 1990 Census found 25 work trips to Reading from Boston Proper, and 246 from the rest of Boston. Of these, 23 were reportedly made by commuter rail. Between 1990 and 1999, total employment in Reading increased by 19%, or 1,124 jobs.

To the west of exit 38, the next exit is Exit 37 in Reading, which connects Route 128 only with Route I-93. The next exit beyond that is Exit 36 in Woburn, which is much closer to the Anderson / Woburn and Mishawum stations on the Lowell Line than to any station on the Haverhill / Reading Line.

In conclusion, there appears to be very limited ridership potential for new transit connections from the Haverhill / Reading Line to points along Route 128 in Wakefield, Lynnfield, or Reading. Service from Boston to the limited market in the vicinity of Exit 38 might best be served by an extension of bus Route 132 and improved coordination with Orange Line service at Oak Grove rather than by a new bus route from Wakefield Station.

Lowell Line

Connections to Woburn

The Lowell Line crosses Route 128 about one quarter mile west of exit 36 in Woburn at Washington Street. Mishawum Station is located just north of the Route 128 crossing. The new Anderson / Woburn Station, about one mile north of Mishawum, opened on April 30, 2000. At the same time, service at Mishawum was reduced to three outbound A.M. peak and three inbound P.M. peak trains. The area around the old and new station sites is one of the most densely developed industrial areas on Route 128, and it has some of the heaviest reverse commuting in the commuter rail system. A December 2000 count found a total of 90 passengers alighting at Mishawum from the five outbound trains then arriving there between 6:00 and 9:30 a.m. This was a slight decrease from the 92 alightings observed from trains in the same interval there in 1996. The 1993 survey showed 82 P.M. peak riders boarding inbound trains at Mishawum for work-to-home trips.

The 2000 count included observations of egress modes from Mishawum Station, but did not determine passenger origins or trip purposes. The most common egress mode was walking, used by 68 riders (74%). Some of these may stop using rail service if the

revised schedule results in less convenient access to their destinations. A van sponsored by one employer was the second most common egress mode, with 12 riders (13%). Loads on individual van trips ranged from one to five. Exits by taxi were third with five riders (5%), at least some of whom had fare vouchers from an employer in Wilmington. Three riders were picked up in private autos, and two transferred to the Logan Express bus. The 1993 survey also showed 12 reverse commuters using connecting van service at Mishawum, so this segment has not grown in absolute terms and has declined slightly relative to other egress methods there.

In the 1990 Census, Woburn had the largest number of reverse commuters from Boston of any Route 128 community north of Boston, and the eighth-largest on Route 128 overall. Specifically, there were 262 reverse commuters from Boston Proper, and 1,050 from the rest of Boston. Between 1990 and 1999, total employment in Woburn increased by 10%, or 3,457 jobs. In both 1990 and 1999, Woburn ranked fourth in total employment among all Route 128 communities. In both total employment and employment of Boston residents, Woburn was far ahead of any community with direct commuter rail service on the lines further to the east. Nevertheless, even with a station at one of the largest concentrations of employment in the city, and availability of dedicated connecting service to some other areas, commuter rail has consistently carried less than 8% of all daily reverse commuters from Boston to Woburn. As shown below, direct express bus service from downtown Boston to other sections of Woburn has also attracted some reverse commuters, but also in small numbers. These results further support the conclusions above that new reverse commuting services using the Newburyport/Rockport and Haverhill/Reading Lines would serve few riders.

MBTA bus Route 355 to Boston originates at Mishawum Station and serves some industrial areas on the south side of Route 128 before entering I-93 to continue to Boston. At present, service only runs outbound in the A.M. peak and inbound in the P.M. peak, so it is not useful as a feeder for reverse commuters using the trains. A Spring 1999 count showed a combined total of only six riders outbound and seven inbound on the two trips a day in each direction.

Additional local-circulation connectors from Mishawum or Anderson/Woburn to employers beyond walking distance and not currently offering some form of pick-up and drop-off service could be expected to attract some additional riders, but the number going to any one employment site would be small. The heaviest demand would not be for service along Route 128.

To the east of Exit 36, the next interchange is Exit 37, which connects only with Route I-93. Exit 38, at Route 28 in Reading, has limited employment opportunities around it. As discussed in the Haverhill/Reading Line section, an extension of bus Route 132 would appear to be the best strategy for serving that area if demand warranted. Buses on such an extension could also continue to Mishawum or Anderson/Woburn to provide train connections there. Points further east of Exit 38 are closer to the Haverhill/Reading Line than to the Lowell Line.

To the west of the Lowell Line, the next interchange on Route 128 is Exit 35 at Main Street (state Route 38) in Woburn. There is substantial industrial, commercial, and office development around this exit. Connecting bus service from Mishawum or Anderson / Woburn would be likely to attract some reverse commuters going there, but would serve a larger market if routed over local streets parallel with Route 128 rather than on Route 128 itself. At present, MBTA bus Route 134 to North Woburn from Wellington Station on the Orange Line runs past Exit 35. This route also runs past Winchester Station on the Lowell Line. The scheduled running time from Winchester Station to Exit 35 is about 15 minutes. Only one outbound A.M. peak train has a good connection with a Route 134 bus. Excluding differences in waiting times, total in-vehicle time from Boston to Exit 35 would be about four or five minutes less using a new bus connection from Anderson / Woburn or Mishawum than by using Route 134 from Winchester. Route 134 passenger counts from 1998 showed nine passengers alighting all day from northbound buses at the stop nearest the south side of Route 128 and 37 at the stop nearest the north side. Inbound all day there were 38 boardings at the north side stop and six at the south side stop.

Connections to Burlington

West of Exit 35, the next four interchanges on Route 128 are all in Burlington, which ranks only slightly behind Woburn both in total employment and in employment of Boston residents. In 1990 there were 268 reverse commuters from Boston Proper, and 917 from the rest of Boston. Between 1990 and 1999, total employment in Burlington increased by 16%, or 5,262 jobs. Several MBTA bus routes can be used for reverse commuting between Boston and points in Burlington, but they have had limited success in attracting such riders.

West of Exit 35, the first interchange in Burlington is Exit 34 at Winn Street. Development around that exit is predominantly residential. It is theoretically possible to travel from Boston to Exit 34 using a combination of the Red Line to Alewife Station, MBTA bus Route 350 to Cambridge Street at Lexington Street in Burlington, and the town of Burlington's B Line Bus Route 4, but the fastest possible trip would take almost two hours. Given the land use characteristics around Exit 34, it would not be worthwhile to run a reverse commuting connection from the Lowell Line, however.

West of Exit 34, the next Burlington interchange is Exit 33 at Cambridge Street. MBTA bus Route 354 from downtown Boston terminates in an industrial area on Wayside Road off Cambridge Street just south of Exit 33. Service includes five outbound A.M. peak trips and five inbound P.M. peak trips. The scheduled running time from downtown Boston to Wayside Road is 40 minutes. Most of the service on the route is scheduled for work trips to Boston. In a Spring 1999 count, the stops south of Route 128 in Burlington had 20 outbound alightings and 21 inbound boardings all day. These may not all have been reverse commuting trips.

Another alternative is to use a combination of the Red Line to Alewife and MBTA bus Route 350 to Wayside Road. Total in-vehicle travel time from downtown Boston via this combination is also about 40 minutes, but additional time must be allowed for the

transfer at Alewife. In Spring 1999 counts, that route had 49 outbound offs but only 18 inbound ons all day at the stops south of Route 128 in Burlington. (The directional discrepancy was apparently a result of differences in routings used at different times of day. The most heavily used stops on the route are on a segment serving the Burlington Mall, which is bypassed on most peak-period trips.

A.M. peak scheduled train times from North Station to Anderson / Woburn range from 20 to 25 minutes, depending on the number of intermediate stops. (Only one train takes less than 23 minutes.) Times to Mishawum are 22 to 24 minutes. Including a transfer allowance, a new non-stop bus from Anderson / Woburn or Mishawum could arrive at Exit 33 at the soonest about 10 minutes after arrival of a train from Boston. This would make a total travel time of 30 to 35 minutes from North Station. The saving compared with bus Route 354, which offers a one-seat ride, would probably not attract many new reverse commuters.

West of Exit 33, the next Burlington interchange is Exit 32B at Middlesex Turnpike. MBTA bus Route 351 from Alewife Station to the Oak Park Drive office complex in Bedford runs directly past Exit 32B. The scheduled time to there from Alewife is about 15 minutes. Total in-vehicle travel time from downtown Boston via the Red Line and Route 351 would be about 33 minutes, but additional time must be allowed for the transfer at Alewife. Nevertheless, it does not appear that a bus connection from the Lowell Line would reduce total travel time from Boston to Exit 32B significantly if at all.

Route 351 currently has six outbound A.M. peak trips and seven inbound P.M. peak trips. In 1998 counts, all stops combined in Burlington had 36 outbound offs and 20 inbound ons. Stops in Bedford had another 47 outbound offs and 40 inbound ons. These would have included riders who boarded the Red Line in Cambridge or who arrived at Alewife by connecting buses as well as riders from downtown Boston.

The last interchange in Burlington is Exit 32B, just west of Exit 32A. It connects Route 128 only with U.S. Route 3, which only runs north from there. (The southerly continuation of Route 3 diverges from Route 128 at Exit 33.)

The findings above indicate that existing MBTA bus routes from downtown Boston and Alewife Station are serving reverse commuters from Boston to Burlington about as well as or better than they could be served by new connecting services from the Lowell Line.

Connections to Lexington

South of Exit 32B, the next three interchanges on Route 128 are all in Lexington. The first of these is Exit 31 at Bedford Street (state Routes 4 and 225). MBTA bus Route 62 from Alewife to Bedford runs directly past Exit 31, with stops on either side. Bus Route 351 runs past Exit 31 on Route 128 but does not stop near there. The scheduled time on Route 62 from Alewife to Exit 31 is about 28 minutes. This is longer than the time on Route 351 from Alewife all the way to Exit 32B. Much of the distance covered by Route 62 is on local streets, but most of that on Route 351 is on limited-access highways.

Development in the immediate vicinity of Exit 31 is mostly residential, but there is an industrial and office park along Hartwell Avenue north of Route 128. Hartwell Avenue is also one of the main access routes to Hanscom Field. Passenger counts on Route 62 in 1998 showed only two outbound alightings all day at the last stop before Route 128 and 28 at the first stop after Route 128. Return boardings from these stops totaled 20 and two. Route 62 does not run directly on Hartwell Avenue on weekdays. The stop nearest to it had 24 outbound offs and 12 inbound ons all day. The opposite end of Hartwell Avenue can be reached from the end of MBTA Route 76 at Hanscom Field, but the running time to there from Alewife is 39 minutes.

For a passenger using a combination of the Red Line and Route 62, the total in-vehicle travel time from downtown Boston to Exit 31 would be about 46 minutes, but additional time must be allowed for the transfer at Alewife. If Route 351 included a stop at Exit 31, total in-vehicle time would decrease to about 31 minutes. A combination of commuter rail to Anderson/Woburn or Mishawum and a non-stop bus to Exit 31 would be faster than the present combination of the Red Line and Route 62, but would be no faster than a combination of the Red Line and a bus using the Route 351 alignment from Alewife. Connections to exits further from the Lowell Line than Exit 31 would all be faster from Alewife.

Intermediate Area between Lowell and Fitchburg Lines

One of the longest gaps between commuter rail line crossings of Route 128 is that between the Lowell and Fitchburg Lines. At one time, the Lexington Branch crossed about mid-way between them near Exit 31, but it was never heavily patronized and the right-of-way has been converted to the Minute Man Bikeway. Plans to extend the Red Line along this alignment to Route 128 have been dropped because of insufficient projected ridership as well as local opposition. This leaves the Red Line Alewife terminal on the border of Cambridge and Arlington as the most convenient rail facility for access to a large section of Route 128, although it is about seven miles away at the closest.

Lexington ranks below both Woburn and Burlington in total employment, in employment of Boston residents, and in employment growth. In 1990 there were 138 reverse commuters from Boston Proper, and 723 from the rest of Boston. Between 1990 and 1999, total employment in Lexington increased by 10%, or 2,016 jobs.

At Exit 31, the direction of Route 128 changes from generally east-west to generally north-south. The next interchange south of Exit 31 is Exit 30 at Marrett Road in Lexington. As discussed above, it would be possible to provide faster overall service to Exit 31 from Boston with a new bus connection from Alewife Station than with a new connection from the Lowell Line. Therefore, connections to Exit 30 or exits further south would also be faster from Alewife. At present MBTA bus Route 76 from Alewife to Hanscom Field runs directly past Exit 30. Like Route 62, it runs for much of the way on local streets. The scheduled time from Alewife to Exit 30 is about 31 minutes. A non-stop routing via Route 2 and Route 128 would take only about 10 minutes from

Alewife to Exit 30. There is some development immediately west of Exit 30, but as at Exit 31, the largest sources of employment served from this exit would be at Hanscom Field and along Hartwell Avenue. There would be insufficient demand to support two different routings to these locations from Alewife. A routing via Exit 30 would be faster to most destinations than a routing via Exit 31.

Route 76 passenger counts from 1998 showed only three outbound offs and six inbound ons all day at the last stop inside Route 128. The rest of the route outside Route 128 had 137 outbound offs and 122 inbound ons. For the route as a whole, 87% of the riders were going to or from Alewife, and most probably transferred to or from the Red Line. A much faster routing between Alewife and Route 128 via Route 2 would be expected to divert most of the riders now traveling at least that far on Route 76, and would also be expected to attract new riders.

The next interchange south of Exit 30 is Exit 29 at state Route 2 in Lexington. Some of the most dense development of office and industrial parks in the Route 128 corridor begins at about this point and continues south on both sides of the highway throughout its length in Waltham. Interchanges in Waltham are Exit 28 (Trapelo Road), Exit 27 (Totten Pond Road / Winter Street), and Exit 26 (Weston Street / U.S. Route 20).

Waltham has by far the highest total employment of any city or town along Route 128, at about 63,000, and also has the second-highest employment of Boston residents. In 1990 there were about 590 reverse commuters from Boston Proper, and 4,390 from the rest of Boston. Because of the limited amount of remaining vacant land suitable for industrial or office development, employment in Waltham is stable. Between 1990 and 1999, total employment there increased by only 1%, or 550 jobs.

The Route 128 Area Business Council sponsors shuttle routes from Alewife Station serving office parks just east of Route 128 in Lexington and on both sides of Route 128 as far south as Exit 27 in Waltham. During A.M. peak hours, service is provided by two routes on headways of 20-30 minutes. In P.M. peak hours it is split into three routes with three inbound trips each. Except for one P.M. peak route, these do not operate directly on Route 128 but follow frontage roads and make numerous pull-offs at employment complexes. In the A.M., the only boarding point is Alewife, and drop-off stops can be varied according to demand. In the P.M., it is necessary to make all stops to look for possible passengers. A.M. running times are not published, but P.M. times are as long as 50 minutes from first stop to Alewife.

Employers on the east side of Route 128 between Exit 28 and Exit 27 are also served by MBTA bus Routes 70A from Central Square in Cambridge and 170 from Dudley Square and Back Bay in Boston. Both of these routes run past the Waltham Station on the Fitchburg Line, and are described further in the discussion below of that line.

Fitchburg Line

The Fitchburg Line crosses Route 128 at Exit 26 (U.S. Route 20) on the border of Waltham and Weston. Brandeis/Roberts Station is one half mile inbound of this point by rail, but access from that station to Route 128 is very indirect. The nearest interchange to the station is Exit 25 (Route 30) on the border of Newton and Weston. It is about 1.5 miles by road from Brandeis/Roberts. The total driving distance from the station to Exit 26 including doubling back on Route 128 is about 3.5 miles. Outbound from Route 128, the nearest station on the Fitchburg Line is Kendal Green in Weston. It is 1.1 miles by rail and about 1.5 miles by road from Exit 26.

Total employment in Waltham is discussed in the preceding subsection. There are no major employers in the immediate vicinity of Exit 26 and also easily accessible from it. There are a few small office parks within walking distance of Brandeis/Roberts Station, however. The area of heaviest industrial and office park development along the Route 128 corridor in Waltham begins just north of state Route 117, which crosses Route 128 but has no direct connection with it.

MBTA bus Route 70 from Central Square in Cambridge to Cedarwood in Waltham includes a stop near the crossing of Routes 117 and 128, but does not provide direct service into the industrial areas. A 1998 count found 58 outbound trips and 52 inbound trips all day at this stop, but actual origins and destinations of passengers were not determined. Route 70 also includes a stop at Waltham Station on the Fitchburg Line, about 1.8 miles by road from Route 128 at Route 117. A.M. peak outbound bus headways range from 17 to 20 minutes, but bus and train times are not well coordinated. As a result, passengers alighting from any of the three outbound trains at Waltham would have to wait for 10 to 15 minutes for Route 70 buses. The running time from the station to Route 128 is about eight minutes, and most passengers going to the employment areas would have long walks from the last bus stop.

MBTA bus Route 170 from Dudley Square and Back Bay serves the frontage roads of the Waltham industrial areas on the west side of Route 128 from Route 117 to Exit 27 (Winter Street) and on the east side from there to Exit 28 (Trapelo Road). The latter segment is also served by the routes from Alewife Station discussed above. Unlike those routes, Route 170 buses do not pull off the frontage road to provide direct-to-door service at employment areas. At present, there are two outbound A.M. peak trips and one inbound P.M. peak trip. The buses run past Waltham Station, but the morning trips both leave there earlier than the first outbound train. Fall 2000 counts showed a total of 19 passengers alighting from the two outbound trips at stops on the roads along either side of Route 128 in Waltham. Only three riders boarded the inbound evening trip in the same area. These totals may have included some trips entirely within Waltham.

MBTA bus Route 70A from Central Square in Cambridge to North Waltham also provides outbound A.M. peak and inbound P.M. peak service to the employment areas on the east side of Route 128 between Exit 27 and Exit 28. This route includes a stop at Waltham Station. A.M. peak Route 70A headways range from 28 to 41 minutes.

Connecting times with the three outbound trains range from 10 to 23 minutes. The running times from the station to employment areas range between about 15 and 20 minutes. Train time from North Station to Waltham Station is 20 to 23 minutes additional. The choice between using Route 70A or the routes from Alewife to reach this area would depend partly on the inner trip end and the relative convenience of access to the Red Line or the Fitchburg Line. In a 1998 count, Route 70A had 94 outbound A.M. offs and 84 inbound P.M. ons in the segment nearest Route 128. Passengers can board at numerous local stops in Cambridge, Watertown, and Waltham, so offs at the Route 128 industrial areas did not necessarily include riders from Boston.

During 2000 an employer-sponsored van route ran three outbound A.M. peak trips and three inbound P.M. peak trips from Waltham Station to the Bay Colony Corporate Center in Waltham. Scheduled connections with outbound A.M. peak trains ranged from two to 17 minutes. The same van trips had connections of five to 17 minutes with inbound trains. As of November 2000, this route was carrying about 20 to 25 riders each way per day, but no information was available on how many of these transferred to or from trains. This route was subsequently replaced by the service described below.

In December 2000 a new city-sponsored local bus network (now called Waltham Citibus) began operating six routes radiating from Waltham Station. These include two routes to industrial and office parks along Route 128. Route 11 goes to the Bay Colony Corporate Center via Main Street and Bear Hill Road. Route 12 goes to the same destination via Lexington Street and Totten Pond Road. Scheduled end-to-end running times are 25 minutes via Route 11 and 21 minutes via Route 12. In the A.M. peak Route 11 buses leave the station at 7:00, 8:00, and 9:00 and Route 12 buses leave at 6:30, 7:30, 8:30, and 9:30. Outbound Route 11 buses return via Route 12 and outbound Route 12 buses return via Route 11 after layovers of five and nine minutes at Bay Colony.

Outbound Fitchburg Line trains are scheduled to arrive at Waltham Station at 7:48, 8:43 and 9:15. The 7:48 train would have a 12-minute connection to Route 11, but a 42-minute wait for Route 12. The 8:43 train would have a 17-minute wait for Route 11, but the 9:15 train would also arrive before the next departure of Route 12. That bus trip, 15 minutes after the arrival of the 9:15 train, would not reach any destinations before the end of the A.M. peak. There would be no travel time advantage by riding Route 11 to Bay Colony and continuing inbound on Route 12 instead of transferring to Route 12 at Waltham Station. A CTPS one-day observation in May 2001 found that at most three of the 11 riders boarding the 8:00 Route 11 trip at the station transferred from the 7:48 train. There were no other transfers to Citibus routes from outbound A.M. peak trains.

Feeder routes scheduled for closer connections with Fitchburg Line trains at Waltham Station could provide better service than is now available to the employment areas along the Route 128 corridor in Waltham, but would still be inconvenient for most workers compared with driving. Bus connections from Kendal Green would be slightly faster than from Waltham, but the extra seven minute train time from Waltham to Kendal Green would exceed the saving. Waltham is also in a lower fare zone (Zone 2 versus Zone 3).

There are no major employers along Route 128 between Exit 26 and Exit 25. Exit 25 is closer to the Framingham / Worcester Line than to the Fitchburg Line. On the opposite side of Route 128 from Waltham, Weston has the third-lowest total employment along Route 128, but is slightly above average in the percentage of its workers that it draws from Boston. In 1990 there were about 60 reverse commuters from Boston Proper, and 170 from the rest of Boston. Between 1990 and 1999, total employment in Weston was almost unchanged.

The Fitchburg Line provides the only public transportation service to Weston at times suitable for reverse commuting, but none of the stations are close to significant employment areas within the town.

Framingham/Worcester Line

This line crosses Route 128 near the Exit 23/24/25 complex on the border of Newton and Weston. The nearest stations are Auburndale, about 0.7 miles by rail inbound and Wellesley Farms, about 1.2 miles by rail outbound. Plans for a new station in Weston just west of Route 128 have been dropped for lack of space. At present, no outbound A.M. peak trains stop at Auburndale, because scheduling constraints require them to run through the station on a track that has no platform. Wellesley Farms has platforms on both tracks but only the last outbound A.M. peak train stops there. This is partly for safety reasons, as passengers going to and from outbound trains would have to walk across both tracks at times when inbound trains were approaching.

Even if it were feasible to stop more outbound trains at Auburndale or Wellesley Farms, there would be little benefit from operating connecting buses along Route 128 from these stations. Newton employs more Boston residents than any other community along Route 128, but the majority of the Newton job locations are outside that corridor. There is one small office park near the Weston side of Exit 23/24/25, but otherwise most of the land around the interchange is residential or is used for parks and golf courses.

To the north of Exit 23/24/25 the next interchange is Exit 26 at Route 20 in Waltham. Connecting service to the area near that exit and further north along Route 128 could be provided better by connections from the Fitchburg Line.

South of Exit 23/24/25, the next interchange is Exit 22 at Grove Street in Newton. This exit is close to Riverside Station, which has much more frequent one-seat ride service from Boston both via the Green Line D Branch and by MBTA express bus Route 500 than could be provided at best on the commuter rail line. Route 500 has faster times to Riverside from the South Station area than trains would have only as far as Auburndale. At present, all of the outbound A.M. peak buses on Route 500 have made previous inbound trips. Running time variations caused by Central Artery construction result in unreliable departure times that discourage ridership. Schedule adjustments could, however, improve the reliability of this service at much less cost than that of rebuilding Auburndale Station to allow outbound A.M. peak trains to stop there.

The next interchange south of Exit 22 is Exit 21 at state Route 16 in Newton. The largest individual employer in this vicinity is the Newton-Wellesley Hospital, which is within walking distance of Woodland Station on the Green Line. Other employers would be better served by connections from Route 500 at Riverside than by connections with train service at Auburndale.

The next interchange south of Exit 21 is Exit 20 at state Route 9 in Wellesley. The Wellesley Office Park adjoins this interchange to the east, and some new office development is occurring to the west. Most of the employment in the town is far-removed from Route 128, however. Wellesley is the seventh-largest employer of Boston residents along Route 128, with 94 from Boston Proper and 1,321 from the rest of Boston in 1990. Total Wellesley employment increased by 6%, or 1,415 jobs between 1990 and 1999.

Eliot Station on the Green Line is about one mile from Exit 20, compared with 2.5 miles via the most direct route from Auburndale, which would run directly past Riverside Station. South of Exit 20, interchanges on Route 128 are closer to the Needham Line than to the Framingham / Worcester Line. As discussed in chapter 6, a new van service from Wellesley Hills Station to some of the employment areas along Route 128 in Needham began running in November 2000, but it attracted few riders and was discontinued in May 2001.

In conclusion, because of operating logistics problems and limited potential ridership, additional connections from the Framingham / Worcester Line to employment areas along Route 128 are not worth pursuing at this time.

Needham Line

This line crosses Route 128 about one half mile north of Exit 18 (Great Plain Avenue) in Needham. West Roxbury Station is 2.1 miles inbound from this location and Hersey Station is 0.4 miles outbound. The land along the east side of Route 128 north and south of the rail line is park land in the flood plain of the Charles River, with no chance of development. The land along the west side of the highway is either residential or unsuitable for building.

The next interchange north of Exit 18 is Exit 19 at Highland Avenue in Needham. This exit directly adjoins the New England Business Center, which is the largest office park in Needham. The Needham commuter rail line turns north at Needham Junction and ends at Needham Heights, 0.75 miles south of Exit 19 along Highland Avenue. A bus connection to the Business Center would be much shorter from Needham Heights than from Hersey, but would involve an added 11 to 24 minutes of on-train time. (The reason for this large range is that two of the three outbound A.M. trains have to wait for inbound trains at the passing siding east of Needham Junction.)

Newton Highlands Station on the D Branch of the Green Line is 1.6 miles by road from Exit 19. Newton Highlands is on the same side of Route 128 as the Business Center, and

is closer than either Needham Heights or Hersey to any point in that office park. The Route 128 Area Business Council sponsors a shuttle van from Newton Highlands Station to the New England Business Center and other nearby office buildings. There are five outbound A.M. peak trips and four inbound P.M. peak trips. Scheduled running times from Newton Highlands to individual office buildings range from six to 28 minutes. As of November 2000, this route was carrying about 35 to 40 riders each way per day.

The outbound A.M. peak running time on the Green Line from Park Street Station to Newton Highlands is about 25 to 30 minutes, compared with commuter rail times of 27 to 32 minutes to Hersey and 39 to 56 minutes to Needham Heights from South Station. Hersey and Needham Heights are both in commuter rail fare Zone 2, with fares ranging from \$2.75 for a single ride to \$2.24 with a monthly pass used for 42 round trips. The unequal inbound and outbound Green Line fare results in an average cost of \$1.75 each way for a single-ride fare or \$1.36 with a pass.

Passengers who would need to go to downtown Boston to access either the D Line or the Needham Line would be most likely to choose the D Line to travel to the New England Business Center area, because of the greater frequency, shorter travel times, and lower fares. The Needham Line does offer the advantage of direct service from Roslindale and West Roxbury, and connections from other residential sections of Boston can be made at Forest Hills via buses or the Orange Line. Spring 2000 counts found that the three outbound A.M. peak trains on the Needham Line left downtown Boston with a total of about 90 riders going to all stations from Forest Hills through Needham Heights.

Needham is the sixth-largest employer of Boston residents along Route 128, with 131 from Boston Proper and 1,644 from the rest of Boston in 1990. Total Needham employment decreased by 4%, or 669 jobs between 1990 and 1999, partly as a result of conversion of manufacturing space to other uses.

To the south of Exit 18, the next two interchanges on Route 128 are Exits 17 and 16 at state Routes 135 and 109, both in Dedham. These exits and the highway segments adjoining them are in sparsely developed sections of the town with little employment. Segments of Route 128 south of Exit 16 are closer to the Franklin Line than to the Needham Line. In conclusion, new connections from the Needham Line to employment areas along Route 128 would not improve travel times for significant numbers of reverse commuters from Boston.

Franklin Line

This line crosses Route 128 between Exit 15 (U.S. Route 1) and Exit 14 (East Street) on the border of Dedham and Westwood. Dedham Corporate Center Station is located just inbound of the Route 128 bridge, but has road access only from the East Street end. Thus far, relatively little development has occurred in the immediate vicinity of the station. There are several businesses along Route 1 north of Route 128, but pedestrian

access to them from the station is poor. An employer-sponsored minibus route runs from Route 128 Station on the Attleboro/Stoughton Line to Dedham Corporate Center Station, but only two outbound A.M. peak trains stop at the latter location. A CTPS count in April 2000 found 12 passengers alighting at Dedham Corporate Center from the earlier train but only one from the later train.

Dedham is the fourth-largest employer of Boston residents, along Route 128, with only 15 from Boston Proper but 2,504 from the rest of Boston in 1990. Total Dedham employment increased by 7%, or 956 jobs between 1990 and 1999. Route 128 runs along the southwest border of Dedham, so almost all employment locations in the town are on the Boston side. On the opposite border from Route 128, Dedham adjoins residential sections of Boston. At present, the outbound train that arrives at Dedham Corporate Center at the time that would be convenient for the most reverse commuters makes no stops in Boston except South Station.

North of Exit 15, the next interchange is Exit 16, which is in a sparsely developed section of Dedham and is about as close to the Needham Line as to the Franklin Line. South of Exit 14, the next interchange is Exit 13, which adjoins Route 128 Station on the Attleboro/Stoughton Line.

On the opposite side of Route 128 from Dedham is Westwood, which ranks twelfth along that highway in employment of Boston residents. In 1990, 69 residents of Boston Proper and 776 from the rest of Boston worked in Westwood. Total Westwood employment increased by 7%, or 598 jobs between 1990 and 1998, but both older and newer jobs were concentrated in the area close to Route 128 Station. Islington Station is in Westwood, about one half mile outside Route 128. At present, no outbound A.M. peak trains stop there, but the same area can be reached by MBTA bus Route 34A from Forest Hills. There are nine outbound bus trips arriving at Islington between 6:30 and 9:30 a.m. The scheduled running time from Forest Hills is 24 minutes. Orange Line time from downtown Boston, excluding transfer time, would add 17 minutes to this. The fastest possible commuter rail time from South Station to Islington would be about 23 minutes, but as can be seen from the figures above, very little of the work travel from Boston to Westwood comes from downtown Boston.

In conclusion, there does not appear to be demand for additional connecting service from Dedham Corporate Center Station along Route 128 or to adjoining areas.

Attleboro/Stoughton Line

This line crosses Route 128 just south of Exit 13 (University Avenue) on the borders of Dedham, Westwood, and Canton. Route 128 Station is located just outbound of the Route 128 bridge, and is accessed from University Avenue. Reverse commuting ridership at this station is the highest at any station at or near Route 128 on the South Side commuter rail lines. During A.M. peak hours five outbound trains stop there. Spring 2000 CTPS counts showed a total of 104 passengers alighting at Route 128 from these trains, but they were not necessarily all making home-to-work trips. There are

several industrial and office buildings along University Avenue within walking distance of the station. In addition, an employer-sponsored minibus route runs from the station to several employment locations in Westwood, Norwood and Dedham, ending at the Dedham Corporate Center Station on the Franklin Line. Scheduled van times to destinations furthest from Route 128 Station range up to 46 minutes. In contrast, scheduled train times from South Station to Route 128 are only 17 to 20 minutes. All five trains stop at Back Bay five minutes after South Station, and three stop at Ruggles eight minutes after South Station, making average times on trains much shorter than those on the van portions of rides.

North of Exit 13, the next interchange is Exit 14, which adjoins Dedham Corporate Center Station, discussed above. South of Exit 13, the next Interchange is Exit 12, in Canton, where I-95 turns south and I-93 diverges east. There is no access to local streets at this exit.

Under the present numbering system, Route 128 ends at exit 14, but the segment of I-93 between there and state Route 3 in Braintree was originally also part of Route 128, so it is also included in this analysis. Route 128 Exit 14 is also I-93 Exit 1. At this point, the alignment of I-93 is generally east-west. The next interchange to the east of Exit 1 is Exit 2 at state Route 138 in Canton. There is an office building adjoining this exit, but there is no transit link and no pedestrian access to it from Route 128 Station. A reverse commuting bus runs from downtown Boston to the Canton Commerce Center, about three miles south of I-93 on Route 138. This bus connects with the Red Line at Quincy Adams Station. A Spring 2000 count showed a total of only seven riders on the three outbound A.M. peak trips.

The next interchange east of Exit 2 is Exit 3 at Ponkapoag Road in Milton. Except for a small residential area, the land surrounding this interchange is part of the Blue Hills Reservation. The exit does not provide convenient access to any employment area. Points along I-93 east of Exit 13 are closer to Quincy Adams Station on the Red Line than to Route 128 Station. The Red Line offers much more frequent service at lower fares than the Attleboro/Stoughton Line, so links from Quincy Adams would potentially be more attractive to reverse commuters than links from Route 128.

Employment in Dedham and Westwood is discussed in the Franklin Line subsection above. Canton ranks slightly ahead of Westwood in employment of Boston residents. In 1990 Canton attracted 86 reverse commuters from Boston Proper and 948 from the rest of Boston. Between 1990 and 1999, total employment in Canton increased by 4%, or 821 jobs. Milton attracted fewer reverse commuters than Westwood, with 42 from Boston Proper and 649 from the rest of Boston. Between 1990 and 1999, total employment in Milton increased by 18%, or 947 jobs. Except for a small area near Exit 3, Milton is entirely inside Route 128. The largest part of the employment is on the side of town nearest Boston, and could not be served efficiently by any bus route running along Route 128.

In conclusion, there does not appear to be demand for additional connecting service from Route 128 Station along Route 128 or to adjoining areas.

Old Colony Lines

Route 128 as currently designated does not intersect the Old Colony lines, but the portion of state Route 3 in Braintree which was originally part of Route 128 does. For this reason the Old Colony lines are included in this analysis.

The Middleborough/Lakeville and Plymouth/Kingston branches of the Old Colony Lines use the same tracks between Boston and a point just south of Braintree Station. The shared line crosses Route 3 about half way between Exit 18 (Washington Street) and Exit 17 (Union Street) in Braintree. The rail line and highway are parallel in this area. Braintree Station is about one quarter mile west of Exit 17.

At present, the two Old Colony lines provide a combined total of three outbound A.M. peak trips to Braintree, with scheduled running times of 17 minutes from South Station. The Red line also runs between South Station and Braintree. It has a scheduled running time of 26 minutes, but offers 21 outbound A.M. peak trips on headways ranging from four to 13 minutes. Also, the Red Line fares are lower. Fall 1999 CTPS counts found only three passengers alighting from outbound A.M. peak Old Colony trains at Braintree, all from one train. In contrast, there were 228 Braintree alightings from outbound A.M. peak Red Line trains. Passengers transferring at Braintree to any connecting bus service on Route 3 would be much more likely to have transferred from the Red Line than from outbound Old Colony trains.

At present, MBTA local bus Routes 230 and 236 both stop at Braintree Station, but neither one operates over Route 3 or any other limited-access highway. The Plymouth and Brockton Street Railway Company (P&B) runs a bus route between Braintree Station and Marshfield via Route 3 with funding from the MBTA Interdistrict Transportation Service (IDTS) program. Service includes one outbound A.M. peak trip and one inbound P.M. peak trip, running non-stop between Braintree and Marshfield. Figures from late 1999 and early 2000 show that these trips rarely carried more than one rider each, and often had none. P&B also runs one outbound A.M. peak trip and one inbound P.M. peak trip between Braintree and the P&B Plymouth Terminal, with one intermediate stop at the Rockland Park & Ride lot. These trips are run mainly to bring buses for peak-direction Marshfield - Braintree trips to and from the garage. A Spring 2000 CTPS count showed only two riders on the inbound P.M. trip, both from Rockland.

Line-By-Line Analysis of Route I-495 Connections

Newburyport/Rockport Line

No station on the Rockport Line is anywhere near any point on I-495. Newburyport Station is the closest point to I-495 on the Newburyport Line. Driving from the station to I-495 would require use of a zigzag path on state Route 113, Route I-95, and state

Route 110 to exit 55 in Amesbury. Historically, Newburyport and Amesbury have not been large attractors of work trips from Boston. The 1990 Census found 12 work trips to Newburyport from Boston Proper and 30 from all of the rest of Boston. There were no work trips to Amesbury from Boston Proper and only 23 from all of the rest of Boston. Between 1990 and 1999 total employment in Newburyport increased by 24%, or 1,961 jobs, and that in Amesbury by 5%, or 212 jobs.

To the east of exit 55, I-495 continues to I-95 in Salisbury, where it ends. There is no local access to either highway there, and the interchange allows only northbound-to-northbound or southbound-to-southbound moves between the two Interstates there. (North/south moves are made via Route 110 and exit 55.) Salisbury had no work trips from any part of Boston reported in 1990.

The next town west of Amesbury is Merrimac, which also had no work trips from any part of Boston reported in 1990. Points in the I-495 corridor west of Merrimac would be closer to stations on the Haverhill/Reading Line than to Newburyport. Between 1990 and 1999, total employment in Salisbury increased by 35%, or 700 jobs, and that in Merrimac by 34%, or 245 jobs.

At the time of the 1990 Census, commuter rail service on the present Newburyport Line had terminated at Ipswich since 1976. Service through to Newburyport was restored in October 1998, including two outbound A.M. peak arrivals and two inbound P.M. peak departures there. It is, however, unlikely that employment of Boston residents in Newburyport, Salisbury, Amesbury, or Merrimac has shown much absolute increase since 1990, even with the addition of this service. C&J Trailways runs through bus service from Boston to a park-and-ride lot on the west side of Newburyport, including one outbound A.M. and one inbound P.M. trip at times suitable for reverse commuting. The scheduled bus travel time is nine minutes less than that of the fastest train, but neither one serves downtown Newburyport. Bus service was also available in 1990, but used a slower inbound P.M. peak routing than at present.

The Merrimac Valley Regional Transit Authority (MVRTA) operates some connecting bus service from downtown Newburyport to the commuter rail station, but it is scheduled to connect with inbound A.M. peak and outbound P.M. peak trains. If any connections for reverse commuters were to be added, they should be run either by the MVRTA or by employers.

Haverhill/Reading Line

The Haverhill/Reading Line crosses I-495 twice, first near Exit 41 on Route 28 at the border of Andover and Lawrence and then at Exit 44 at Merrimack Street on the border of Lawrence and North Andover. There is no station at either of these locations, but Lawrence Station is about 1.4 miles outbound from Exit 41 and about 1.3 miles inbound from Exit 44. The Merrimack Valley Regional Transit Authority operates bus routes from downtown Lawrence along both Route 28 and Merrimack Street. Neither route stops directly at the commuter rail station, but both pass within a few blocks of it. At

present, only one outbound train from Boston arrives in Lawrence during A.M. peak hours, and it does not make good connections with either of these bus routes. Most of the employment in Lawrence is closer to downtown than to I-495, and much of it is within walking distance of the station.

Historically, Lawrence has not attracted large numbers of reverse commuters from Boston. The 1990 Census showed only 45 residents of Boston Proper and only 94 from all of the rest of Boston working in Lawrence, but this was nevertheless the tenth-highest total of any city or town on I-495. The 1993 survey found a total of 13 work-to-home trips from Lawrence to Boston by commuter rail. Between 1990 and 1999, total employment in Lawrence dropped by 3%, or 615 jobs.

The MVRTA also operates numerous other bus routes in Lawrence and surrounding municipalities, but most of them pass even further away from the commuter rail station than those discussed above. The MVRTA does not run service directly on I-495, but does have several routes that serve industrial areas along the I-495 corridor via local streets.

North of Lawrence, I-495 runs through Methuen to Haverhill. The rail line runs through North Andover to Haverhill. There is no stop in North Andover, but in Haverhill there are stations both at Bradford and downtown. The MVRTA runs routes to points along the I-495 corridor from a transit center near the downtown rail station. As at Lawrence, there is only one outbound A.M. peak train, and the bus and train schedules are not well coordinated. The 1990 Census found only 11 work trips to all of Haverhill from Boston Proper and only 19 from all of the rest of Boston. The 1993 survey found a total of five work-to-home trips from Haverhill to Boston by commuter rail. Between 1990 and 1999, total employment in Haverhill grew by 9%, or 1,523 jobs.

Employment of Boston residents in Methuen in 1990 was between that of Lawrence and Haverhill, with nine from Boston Proper and 45 from the rest of Boston. None of the trips were made by rail, according to the 1993 survey. Between 1990 and 1999, total employment in Methuen dropped by 3%, or 435 jobs.

Beyond Haverhill on I-495 are the towns of Merrimac and Amesbury, neither of which showed any work trips from Boston in the 1990 Census. Points beyond these are closer to Newburyport Station on the Newburyport Line than to any station on the Haverhill/Reading Line.

To the southwest of Lawrence, I-495 first passes through Andover. Except in the vicinity of Exit 41, discussed above, it runs mostly through low density residential areas, wetlands and park land, with little or no employment. The 1990 Census showed 58 work trips to Andover from Boston Proper and 229 from all of the rest of Boston. The 1993 commuter rail survey showed six work-to-home trips from Andover to Boston. Total employment in Andover increased by 28% between 1990 and 1999 representing a gain of 6,880 jobs.

Andover is served directly by two stations on the Haverhill/Reading Line, in downtown Andover and at Ballardvale. These are both served by the same outbound A.M. peak train that goes to Lawrence. The MVRTA runs two routes that make stops within one quarter mile of the downtown Andover station and depart from these stops about 20 minutes after the arrival of the outbound A.M. peak train. One of these crosses I-495 at Exit 41 near the border of Lawrence. A third route originates at Ballardvale Station, but does not make a convenient connection with this train.

After Andover, the highway runs through Tewksbury which is closer to stations on the Lowell Line than to the Haverhill/Reading Line.

In conclusion, improved coordination between outbound A.M. peak and inbound P.M. peak trains at Lawrence, Haverhill, or Andover with existing MVRTA bus routes to employment areas might attract small numbers of new riders. There does not appear to be enough potential ridership to justify starting new routes along I-495 designed specifically for commuter rail connections.

Lowell Line

The Lowell Line crosses I-495 near Exit 37, which is on Woburn Street in Lowell. The nearest stations to this are North Billerica, about two miles further inbound and Lowell, about two miles further outbound by rail. The area around Exit 37 is predominantly residential with little potential employment for reverse commuters. This is also true of the rest of the I-495 corridor in Lowell which includes a distance of only about one mile on the southern border of the city. Most employment in Lowell is closer to the Lowell Station than to I-495. The Lowell Regional Transit Authority (LRTA) has an extensive network of bus routes centered on downtown Lowell and serving both Lowell and adjacent towns. Most of these routes do not serve the commuter rail station directly, but there is a shuttle route linking the station with the downtown area and the other routes.

Historically Lowell has had the largest total employment of any city or town along I-495, but it may soon be overtaken. Between 1990 and 1999 employment in Lowell fell by 16%, or 6,561 jobs. Lowell was a distant second to Marlborough in employment of Boston residents in 1990, with 66 from Boston Proper and 232 from the rest of Boston. The 1993 survey found only 15 work-to-home trips from Lowell to Boston by train in the P.M. peak.

The next town to the east of Lowell on I-495 is Tewksbury. Employment in that town is scattered and is mostly away from I-495, which passes through many wetlands. The 1990 Census showed 34 Boston Proper residents and 129 other Boston residents working in Tewksbury. Total employment in Tewksbury increased by 83% between 1990 and 1999 representing a gain of 7,850 jobs.

The next town east of Tewksbury on I-495 is Andover, which is served by the Haverhill/Reading Line. West of Lowell, I-495 first run through Chelmsford and then

through Westford, but mostly in residential areas of both. The 1990 Census showed 34 Boston Proper residents and 137 other Boston residents working in Chelmsford. Total employment in Chelmsford increased by 37% between 1990 and 1999 representing a gain of 5,565 jobs. Westford employed no Boston Proper residents and only 43 other Boston residents. Total employment in Westford increased by 89% between 1990 and 1999 representing a gain of 4,965 jobs. Westford is located halfway between the Lowell and Fitchburg lines. Towns beyond Westford are closer to the Fitchburg Line than to the Lowell Line.

In conclusion, improved coordination between outbound A.M. peak and inbound P.M. peak trains at Lowell with existing LRTA bus routes to industrial areas might attract small numbers of new riders. There does not appear to be enough potential ridership to justify starting new routes along I-495 designed specifically for commuter rail connections.

Fitchburg Line

The Fitchburg Line crosses I-495 at Exit 29 in Littleton. The Littleton / Rte 495 Station is close to this location, but I-495 connects only with state Route 2 there. The shortest path to I-495 from this station involves use of indirect local roads to Route 2 at Taylor Street west of I-495, then doubling back east on Route 2 to Exit 29. The total distance is about two miles. A more direct connection to the station from Route 2 has been proposed but is not yet assured. At present, the earliest outbound train arrives at Littleton / Rte 495 at 9:42 a.m., which is too late for most reverse commuters.

There are relatively few employment attractions for Boston residents within Littleton, either along I-495 or elsewhere. The 1990 Census showed 29 work trips to Littleton from Boston Proper and 71 from all of the rest of Boston. Total employment in Littleton increased by 9% between 1990 and 1999 representing a gain of 500 jobs.

To the north along I-495, exits 30 and 31 are also in Littleton, at state Routes 2A and 119. Both are in mostly residential or undeveloped areas. The next town to the north of Littleton is Westford, which as discussed in the Lowell subsection also has few employment attractions for Boston residents.

South of Exit 29, Exit 28 is at Route 111 in Boxborough. There is a hotel at this exit, but otherwise there are no large employers nearby. The 1990 Census showed only 20 residents of Boston Proper and only 19 from the rest of Boston employed in Boxborough. Total employment in Boxborough decreased by 6% between 1990 and 1999 representing a loss of 115 jobs.

South of Boxborough, I-495 passes through a sparsely developed corner of the town of Harvard with no interchanges. The 1990 Census showed no residents of Boston Proper and only 40 from the rest of Boston employed in Harvard. Total employment in Harvard increased by 5% between 1990 and 1999 representing a gain of 50 jobs.

Exit 27 is at Route 117 in Bolton. Development throughout that town is sparse. The 1990 Census found no workers from Boston Proper and only five from the rest of Boston employed in Bolton. Total employment in Bolton increased by 55% between 1990 and 1999 representing a gain of 800 jobs. Exit 27 is at Route 62 in Berlin. That town had no workers from Boston reported in 1990. Total employment in Berlin increased by 58% between 1990 and 1999 but this was a gain of only 230 jobs. Points south of Berlin along I-495 are closer to the Framingham / Worcester Line than to the Fitchburg Line.

In conclusion, there would be insufficient potential ridership to justify operation of connecting bus service from the Fitchburg Line to points along I-495 even if there were outbound trains arriving at Littleton / Rte 495 Station in the A.M. peak.

Framingham/Worcester Line

This line crosses I-495 next to Exit 22 in Westborough. At that location, I-495 connects only with the Massachusetts Turnpike. Three new stations on this line are currently under construction or in final design. Those nearest I-495 will be in Southborough, 2.2 miles further inbound by rail, and in Westborough, 4.1 miles further outbound by rail. Of these stations, Southborough would make a better starting point for connecting service to points along I-495. For destinations north of the rail line, the shortest path to I-495 would be north and west on state Routes 85 and 9 to Exit 23 in Westborough. For destinations south of the rail line, the shortest path to I-495 would be south and west on state Routes 85 and 135 and West Main Street to Exit 21 in Hopkinton.

At present, there is only one outbound A.M. peak train and one inbound P.M. peak train serving stations west of Framingham (Grafton and Worcester) on this line. These trains have been running only since April 30, 2001. Tentative schedules for service after completion of all the new stations include only two trains that would arrive at Southborough in time for reverse commuters. For additional service, operation of express buses via the Mass. Turnpike would be more cost-effective than operation of more trains.

There are several large employers in office parks just west of Exit 23, and commuter rail connecting services would not have to enter I-495 to reach them. Until recently, the next interchange north of Exit 23 was Exit 24 at U.S. Route 20 in Marlborough. A new interchange opened in 2000 between these exits at Industrial Park Drive in Marlborough. This exit is intended to serve the rapidly growing office and industrial parks along I-495 in Marlborough.

Connecting bus service from the Southborough Station to Marlborough appears to have the best ridership potential of any connecting service on I-495. The 1990 Census showed 144 residents of Boston Proper and 412 residents of other sections of Boston working in all of Marlborough. This was by far the largest number of Boston residents employed in any city or town directly on I-495. Between 1990 and 1999, total employment in Marlborough increased by 31%, or 6,370 jobs. This was the third-largest

absolute gain of any I-495 community. Nevertheless, recent reverse commuting bus service from Boston to Marlborough, which offered a one-seat ride with faster times than would be possible with a train-bus connecting service, attracted almost no riders. (An April 2000 count found only one rider on the one outbound A.M. peak trip. This trip was discontinued in April 2001.)

The largest concentrated area of employment in Hopkinton is in an office / industrial park running along the west side of I-495 south of Exit 21. Buses going there or to any other destination in Hopkinton from the Southborough Station would not enter I-495 at all. The 1990 Census showed only 18 residents of Boston Proper and only 122 from the rest of Boston employed in Hopkinton. Total employment in Hopkinton increased by 131% between 1990 and 1999 representing a gain of 5,100 jobs.

The next two interchanges south of Exit 21 are Exits 19 and 20 at state Routes 85 and 109 in Milford. Bus times to most points in Milford would be faster from Forge Park Station on the Franklin Line than from Southborough Station, but the Franklin Line has only one outbound A.M. peak train. Train time would be slightly less from Boston to Southborough (about 50 minutes, depending on number of intermediate stops) than to Forge Park (55 minutes) partly offsetting the longer Southborough bus time. With current traffic conditions, a through bus from Boston to Milford via the Mass. Turnpike and I-495 would also take only about 50 minutes, however. The 1990 Census showed no residents of Boston Proper and only 90 from the rest of Boston employed in Milford. Total employment in Milford increased by 15% between 1990 and 1999 representing a gain of 1,720 jobs.

Any point along I-495 south of Milford could be reached faster either by a train-bus connection from the Franklin Line or by a through bus from Boston than by a train-bus connection from the Framingham / Worcester Line.

In conclusion, connecting bus service from the Framingham / Worcester Line to employment areas in Marlborough would appear to have the best ridership potential of any such services along the I-495 corridor. Nevertheless, results of recent past bus service, which was faster than train / bus service could be, showed almost no demand for reverse commuting transit service from Boston to Marlborough.

Franklin Line

The Franklin Line crosses I-495 at Exit 17 (state Route 140) in Franklin. The Forge Park terminal is about one half mile outbound from this crossing. The station adjoins the Forge Park Industrial Area and was built in conjunction with it. At present, only one train runs from Boston to Forge Park in the A.M. peak and only two return in the P.M. peak. The ability to increase service is severely limited by the amount of single track on the line and by the frequency of peak-direction trains. Outbound alighting counts have not been done at Forge Park. An April 2000 CTPS count of the one outbound A.M. peak train found only 25 passengers from Boston remaining on board after Dedham Corporate Center to go to all six subsequent stops.

The 1990 Census showed 96 residents of Boston Proper and another 96 from the rest of Boston employed in Franklin. Total employment in Franklin increased by 62% between 1990 and 1999 representing a gain of 4,420 jobs.

North of Exit 17, the next interchange is Exit 18 at state Route 126 in Bellingham. A large new office park has been proposed in this area, but at present there is little development there. The 1990 Census showed no residents of Boston Proper and only 17 from the rest of Boston employed in Bellingham. Total employment in Bellingham increased by 60% between 1990 and 1999 representing a gain of 1,760 jobs.

The next two interchanges are Exits 19 and 20 at state routes 109 and 85 in Milford. As discussed in the Framingham / Worcester Line section, a through bus from Boston to Milford via the Mass Turnpike and I-495 would be faster than any combination of commuter rail and bus.

South of Exit 17, the next interchange is Exit 16 at King Street in Franklin. The Franklin Industrial Park adjoins this exit. Access to this area would be faster via local roads from Franklin Station than via I-495 from Forge Park. Segments of I-495 beyond Exit 17 are closer to the Attleboro / Stoughton Line than to the Franklin Line.

In conclusion, there does not appear to be sufficient demand to justify connecting bus service along I-495 from the Franklin Line.

Attleboro/Stoughton Line

The Stoughton Line currently terminates too far inside I-495 to provide connections to points along that highway. Trains running on the main line to Providence, South Attleboro, or Attleboro cross I-495 near Exit 12 (state Route 140) in Mansfield. The nearest station is Mansfield, about 1.5 miles further inbound by rail, but about three miles by road. There are several industrial buildings along Forbes Boulevard north of the crossing of the railroad under I-495. Highway access to this area from Mansfield Station would not involve use of I-495 at all.

At present, four outbound A.M. peak trains stop at Mansfield. The earliest of these has been running only since April 30, 2001, so it is too soon to evaluate ridership. Spring 2000 counts on the train that was then the earliest showed 10 alightings at Mansfield. Counts were not done there for the other two trains, but based on total Boston boardings and partial alighting counts before Mansfield, each of them would have had only 10 to 15 Mansfield alightings. The results of the 1993 commuter rail survey indicated that the heaviest source of reverse commuters at Mansfield Station was an office park just over the border in Foxborough, to which there was a private van connection. Most of the Foxborough reverse commuters did not come from Boston, however. The 1990 Census showed no residents of Boston Proper but 143 from the rest of Boston employed in Mansfield. Total employment in Mansfield increased by 35% between 1990 and 1999 representing a gain of 3,100 jobs.

At Exit 12, I-495 runs generally east-west. Route 140 is also a limited-access highway at this point, and there is no direct access to local roads. To the west on I-495 the next interchange is Exit 13 at I-95 Exit 6 on the border of Mansfield and Foxborough. There is no access to local roads there. To reach points in Foxborough from I-495 it is necessary to go north 1.3 miles on I-95 to Exit 7 at Route 140. That location can be reached much more directly from Mansfield Station over Route 140 without use of either I-495 or I-95. The office park in Foxborough mentioned above is just off Route 140. The 1990 Census showed 29 residents of Boston Proper and 130 from the rest of Boston employed in Foxborough. Total employment in Foxborough increased by 8% between 1990 and 1999 representing a gain of 720 jobs.

West of Exit 13 on I-495, the next interchange is Exit 14 at U.S. Route 1 in Plainville on the border of Wrentham. At present there is little development in this vicinity, and none planned. Likewise, there is little existing or planned development around Exit 15 at state route 1A in Wrentham. The 1990 Census showed no Boston residents employed in Plainville. Wrentham attracted nine work trips from Boston Proper and 78 from the rest of Boston. Total employment in Wrentham increased by 7% between 1990 and 1999 representing a gain of 320 jobs. Points on I-495 beyond Exit 15 are closer to the Franklin Line than to the Attleboro/Stoughton Line.

East of Exit 12, Route 140 and I-495 follow the same alignment to Exit 11 in Mansfield. Route 140 diverges there as a local road. Development there is mostly residential. The Tweeter Performing Arts Center is also nearby, but the employment there is not conducive to reverse commuting.

East of Exit 11, the next interchange is Exit 10 at state Route 123 in a mostly undeveloped section of Norton. The 1990 Census showed no residents of Boston Proper and only 18 from the rest of Boston employed in Norton. Total employment in Norton increased by 45% between 1990 and 1999 representing a gain of 1,800 jobs.

East of Exit 10, the next interchange is Exit 9 (Bay Street) in the northern edge of Taunton. This exit adjoins the Myles Standish Industrial Park, being developed on the former site of a military reservation. The 1990 Census showed no residents of Boston Proper but 145 from the rest of Boston employed anywhere in Taunton. Total employment in Taunton increased by 16% between 1990 and 1999 representing a gain of 3,125 jobs.

East of Exit 9, the next interchange is Exit 8 at state Route 138 in Raynham. The proposed New Bedford/Fall River extension of the Stoughton commuter rail line would cross I-495 just west of this Exit. A station at or near that point would be closer than any station on the Attleboro line to destinations along I-495 east of exit 10 in Norton. Development around Exit 8 is mostly residential. In the 1990 Census, Raynham had one of the lowest rates of attraction of workers from Boston in the I-495 corridor, with four from Boston Proper and seven from all of the rest of the city. Total employment in Raynham increased by 51% between 1990 and 1999 representing a gain of 2,290 jobs.

East of Exit 8, the next interchange is Exit 7 at state Route 24 on the border of Raynham and Bridgewater. There is no access to local roads at that point. The nearest local access is at Route 24 Exit 15, about 1.5 miles north, but it is in a sparsely developed area surrounded by swamps. This location is much closer to Bridgewater Station on the Middleborough/Lakeville line than to Mansfield. Nevertheless, overall time from Boston via a bus connection from Mansfield would be about the same as that via a bus connection from the fastest train at Bridgewater Station. Most work destinations in Bridgewater are closer to Bridgewater Station than to Route 24, however.

East of Exit 7 the next interchanges are exits 6, 5, and 4, at U.S. Route 44, state Route 28, and state Route 105, all in Middleborough. The existing Middleborough/Lakeville Station on the line of that name is closer than any station on the Attleboro Line to destinations along I-495 east of exit 9 in Raynham. Nevertheless, a bus connection from Mansfield could have an overall time advantage to destinations almost as far along I-495 as Middleborough. The distance from South Station in Boston is 10.5 miles less to Mansfield Station than to Middleborough/Lakeville, and average speeds are higher on the Attleboro Line because of higher top speeds and fewer intermediate stops. Scheduled outbound A.M. peak train times from South Station to Mansfield range from 37 to 38 minutes, compared with 55 to 60 minutes to Middleborough/Lakeville.

In Boston, reverse commuters going to Mansfield can board at South Station, Back Bay, or Ruggles, but Middleborough/Lakeville Line reverse commuters can board only at South Station. Some trains on each Old Colony branch began stopping at the JFK/UMass Station in Dorchester on April 30, 2001, but not none of these stop there at times suitable for reverse commuting. Because of track capacity constraints and low demand potential, it is unclear whether reverse commuting trains will ever stop at JFK/UMass.

A further analysis of potential I-495 connections from the Middleborough/Lakeville Line is contained in the next subsection. There does not appear to be sufficient demand to justify implementation of connecting bus service along the I-495 corridor from the Attleboro/Stoughton Line.

Old Colony Lines

The Plymouth/Kingston branch of the Old Colony lines does not get close to I-495 at any point, but the Middleborough/Lakeville branch crosses I-495 at Exit 4 (state Route 105) just north of Middleborough/Lakeville Station. The heaviest concentration of employment in Middleborough is in the downtown area. It is possible, though not very convenient, to walk downtown from the station. Connecting transit service would not use I-495.

North of Exit 4, the next interchanges are Exits 5 and 6 at state Route 28 and U.S. Route 44, also in Middleborough. These two exits are very close together, and both provide access to an industrial park. South of Exit 4, the next interchange is Exit 3 at state Route 28, also in Middleborough, but in a sparsely developed mostly residential area.

Overall, Middleborough had one of the lowest attraction rates of workers from Boston along I-495 in the 1990 Census, with eight from Boston Proper and five from the rest of Boston. Total employment in the town increased by 14%, or 940 jobs, between 1990 and 1999.

Points on I-495 north of Exit 6 could be reached faster from Boston with a bus connection from Bridgewater Station on the Middleborough /Lakeville line or from a station on another line than with a bus connection from Middleborough /Lakeville Station. Relatively few Boston residents work in towns south of Middleborough, partly because of travel time and distance and partly because of limited employment opportunities there.

Proceeding south from Middleborough, Rochester attracted 16 workers from all of Boston in 1990. Total employment there grew 59%, or 350 jobs, from 1990 to 1999. Wareham attracted seven workers from all of Boston in 1990. Total employment there grew 14%, or 800 jobs, from 1990 to 1999. Bourne, where I-495 ends, attracted 25 workers from all of Boston in 1990. Total employment there grew 15%, or 870 jobs, from 1990 to 1999. In light of relatively high unemployment rates on Cape Cod and in South Coast communities, it would be counterproductive to institute transit services designed to bring more workers into these areas from Boston.

6. CASE STUDIES OF REVERSE COMMUTING SERVICES ON MBTA COMMUTER RAIL

Introduction

Throughout much of the history of the Boston commuter rail system, service has included trains on many lines at times suitable for commuting from homes in Boston to work locations in outlying areas in the A.M. peak and returning home in the P.M. peak. Nevertheless, there have been few attempts to operate services targeted at specific reverse commuting markets either by establishing stations directly adjoining suburban work locations or by operating dedicated connecting services between suburban stations and employment sites. This chapter examines the experience with some known examples of such services in the Boston system.

Stations or Service Established for Individual Employers

United Shoe Machinery Company Service ca. 1908 - 1930

The earliest example found of commuter rail service provided specifically for reverse commuting from Boston dates from nearly a century ago. In 1901, the United Shoe Machinery Corporation built a large factory complex beside what is now the Newburyport commuter rail line, 0.8 miles north of Beverly station. By 1908, the Boston & Maine Railroad was running a special train from Lynn to the USM plant arriving in time for the start of a 7:00 a.m. shift. At Lynn this train made close connections with a train from Boston. At the end of the work day, a special train from USM ran through to Boston. Selected other trains in both directions also stopped at USM. By the end of World War I, the USM complex was reported to have up to 5,000 employees. A shortening of the work day in the late 1920s led to a later departure time of the special train from Lynn, and a longer wait for the Boston connection. By the early 1930s, a reasonable outbound Boston connection was no longer possible.

Service subsequently declined to a single inbound train from Portsmouth, New Hampshire stopping at USM in the A.M. peak, but there was no outbound return service. One inbound train from Newburyport or Portsmouth still stopped at USM up to the time that the MBTA began subsidizing North Side commuter rail service in 1965.

No information on ridership to or from the USM complex is available. The limited frequency offered and the early demise of Boston connections suggest that the trains never carried a large share of USM workers. Also, the fact that it was not followed by institution of similar service to other factory complexes along the rail lines suggests that it was not a great success.

The former USM complex has recently been recycled as the Cummings Center office park. The management of this development has expressed interest in re-establishing a special commuter rail stop there. Under present accessibility regulations, this would require a much more elaborate platform facility than existed in the past. Investment in

such a facility would require a long term commitment to maintaining the service rather than just a short-term service experiment.

Hingham Shipyard Service, ca. 1942 - 45

In 1942, the New Haven Railroad built a spur from the Greenbush Branch of the Old Colony lines into the Bethlehem Hingham Shipyard (now the site of the Hingham commuter boat terminal). This spur was intended primarily to move materials for construction of battleships. By 1944, a special passenger train was being run from Boston directly to the shipyard every morning and return in the evening to carry workers. Total employment in the shipyard reportedly exceeded 20,000 at the time, and a single train could have carried only a small percentage of them. For security reasons, little information about these trains was made public, and their schedules were known only to the passengers and to railroad employees. This service was discontinued at the end of the war.

Rustcraft Service 1955 - 1977

In May 1955, the New Haven Railroad opened a station on what is now the MBTA Franklin Line in Dedham adjoining a new plant of the Rustcraft greeting card company. This station was intended specifically to bring workers to the plant from Boston. At the opening ceremonies it was hailed as the beginning of a new era in commuting. Initially the station was served by two outbound trains leaving South Station at 7:45 and 8:45 a.m. and arriving at Rustcraft at 8:14 and 9:12 and by two return trips leaving Rustcraft at 4:55 and 5:38 p.m. and arriving at South Station at 5:25 and 5:57. The station was only easily accessible through the grounds of the factory, and no peak-direction service was ever offered there. All service was provided by trains that had been running to and from more distant points anyway.

Morning service was reduced to a single trip later in 1955, when the second train was discontinued entirely. In 1959 the train that had provided the later of the two inbound stops at Rustcraft was discontinued. This was done as part of a larger service cutback that left the earlier train as the only inbound one on the line after mid-morning. The oldest available ridership count for Rustcraft station shows an average of 22 weekday inbound riders as of April 1963. Boardings had fallen to 13 by March 1966, and to four by March 1968. By 1971 ridership was averaging only one or two boardings per day, and by 1972 there were usually no riders at Rustcraft.

Apparently the commuters who initially used the service were not replaced by others with similar travel needs as they retired or found new jobs. A reduction in total employment at the Rustcraft plant also contributed to the declining ridership. After merging with another company Rustcraft left Massachusetts. The station was officially discontinued in 1977. Dedham Corporate Center station, about one half mile south of the Rustcraft site, opened in 1990. It serves some reverse commuters, but is used primarily as a park-and-ride facility for travel to Boston.

G.E. River Works Service 1977 -

The General Electric River Works complex occupies both sides of a segment of the Newburyport / Rockport commuter rail line in West Lynn. The earliest predecessors of this complex were located there by the late 1800s. As early as 1915, the Boston & Maine Railroad began stopping one inbound A.M. peak train at the River Works to allow commuting from points as far north as Portsmouth, New Hampshire. Passengers returning home after work apparently had to either go to the Central Square Lynn station 1.8 miles away, or take a local train from the West Lynn Station 0.8 miles away and transfer at Central Square.

The practice of stopping one inbound Portsmouth or Rockport train at the River Works continued until shortly before the start of MBTA funding of North Side commuter rail service in 1965. This service was known to G.E. employees but was usually not shown in public timetables. Reverse commuting service from Boston to the River Works was apparently not offered.

In September 1965, the MBTA re-instituted service to the River Works from the north, but instead of a single train, most A.M. peak trains from both Ipswich and Rockport stopped there. Return service was also offered for the first time, with most outbound P.M. peak trips stopping at River Works. As before, schedules of trains stopping there were made known to G.E. employees, but they did not appear in timetables distributed to the general public until 1989.

The oldest available passenger counts at River Works were done in January 1971, and include only inbound trains. They show an average of 35 riders a day alighting from five inbound A.M. peak trains stopping there. Ridership gradually increased, reaching 95 inbound alightings by 1976. Stops by trains suitable for reverse commuting were gradually added beginning about 1977, but there were still no inbound boardings reported there as late as 1980. In the April 1983 Ticket Audit, there were five inbound P.M. peak riders, and in September 1986 there were 11.

Because of defense contract cutbacks, employment levels at the G.E. complex were substantially reduced during the 1990s. Inbound P.M. peak boardings at River Works station reported in Ticket Audits fluctuated, but rarely exceeded 20 per day. Spring 2000 CTPS counts on two of the three outbound A.M. peak trains stopping at River Works showed four passengers alighting there from each. The third train was not observed. It left Boston with slightly more total riders than the first train, but also made more stops.

Lechmere Woburn Service 1979 - 1996

In 1979 the MBTA established a station adjoining the distribution warehouse of the Lechmere Sales discount department store chain in Woburn. This station was instituted at the request of Lechmere management, to assist Boston area employees who were being transferred to the Woburn site from an older facility in Somerville. This station

was accessible only through the Lechmere grounds, and its use was restricted to Lechmere employees. It was not shown in public schedules until 1982, at which time three outbound A.M. peak and three inbound P.M. peak trains stopped there. Outbound A.M. peak service was reduced to two trips about 1984. Otherwise, the service remained unchanged until 1996, when it was discontinued entirely.

The only available passenger count for this station is an April 1983 Ticket Audit showing a total of 17 inbound boardings. The 1993 commuter rail survey had only one response from a passenger boarding at the Lechmere stop, for a trip home from work to a destination beyond Boston. Mishawum Station in Woburn opened as a full-service stop in September 1984. It is 0.6 miles outbound from the Lechmere site by rail, but somewhat further by road. Lechmere Sales has gone out of business, and present use of the Woburn warehouse was not determined for this study.

Stations with Connecting Service to Employment Areas

Route 128

Route 128 Station on the Attleboro/Stoughton Line was first opened in 1953. Its original main purpose was to give intercity rail passengers from the suburbs a more convenient alternative to traveling to Boston or Providence to board. Throughout the time that there has been a station at this location it has had some service suitable for reverse commuting, but it originally had no nearby sources of employment. Extensive development along University Avenue did not begin until the early 1970s; prior to that, the only industry around the station was gravel pits.

In 1974 only one inbound commuter train stopped at Route 128 in the P.M. peak, leaving there at about 6:00. An April 1974 Ticket Audit showed only one or two riders a day boarding that train there. Outbound A.M. peak service there increased from one train to three in May 1974, when two former non-revenue trains to Stoughton began carrying passengers.

In 1979 reverse-commuting service frequency at Route 128 was the same as in 1974, but the one inbound P.M. peak train left Route 128 at about 4:00. A March 1979 Ticket Audit showed five passengers boarding that train at Route 128.

Frequency increased over the next few years, but as a result of changes in overall service patterns rather than of increased demand at Route 128. By April 1983 there were four outbound A.M. peak and three inbound P.M. peak trains. A Ticket Audit then showed 38 boardings on the P.M. peak trains at Route 128, but this would have included non-commuting trips. By the time of the 1993 commuter rail survey, six inbound P.M. peak trains stopped at Route 128. The survey indicated that 21 of 33 riders boarding these trains there were traveling from work to home, including 12 with final destinations in Boston.

Spring 2000 CTPS counts found a total of 104 riders alighting from the five outbound A.M. peak trains stopping at Route 128, with individual totals ranging from 15 to 30 per train. Trip purposes were not determined. Counts were done at Route 128 for only two of the four inbound P.M. peak trains stopping there as of Spring 2000, but the Boston alighting totals for all four suggest that inbound P.M. peak boardings at Route 128 would have been at least as great as outbound A.M. peak alightings. A December 2000 outbound A.M. peak count at Route 128 showed a decrease from the Spring, to 87 alightings. Individual totals in December ranged from 15 to 20 per train.

Factors contributing to the substantial growth in apparent reverse commuting traffic at Route 128 during the 1990s included new development within walking distance of the station, displacement of some earlier warehousing sites with offices having higher employment density, and institution of connecting minibuses from the station to employment areas beyond convenient walking distance. This service was initially funded through the Neponset Valley Transportation Management Association, but more recently it has been funded directly by companies whose workers it serves.

As of December 2000, the Route 128 minibus service was reported to be carrying about 50 riders a day in the A.M. peak and 20 in the P.M. peak, but detailed figures were not available. The discrepancy between A.M. peak and P.M. peak ridership was a result of less convenient train connections in the P.M. peak as well as a smaller number of employers contracting for P.M. peak service. Presumably, workers who used the minibus service only in the A.M. found other means to return to the station or to travel home without riding the commuter rail line in the P.M. peak.

The December 2000 CTPS counts at Route 128 included observations of the means of egress from the station used by passengers after alighting from trains. Of the 87 outbound alighting riders, 52 (60%) used the minibus and 28 (32%) walked. Of the rest, two each were picked up by private autos or taxis, two drove away in parked cars, and one rode a bicycle. Passengers transferring to the bus can be presumed to have been going to work, but the others would have included some non-work trips. These figures imply that without the bus service, the number of reverse commuters would have increased much less compared with the 1993 survey results. The greatest number of bus transfers from any individual train was 16, from the train due at 7:03. Another 15 transferred to the bus from the train due at 8:12. The bus was also used by three of the four riders alighting from an outbound train arriving at 5:56 a.m., before the start of the peak as defined for this study.

In the A.M. peak there were also nine inbound trains stopping at Route 128, compared with only five outbound trains. Only 21 passengers alighted from the inbound trains, and only two of these (10%) transferred to the bus. This suggests that in estimating demand for connecting services at other stations, reverse commuters would account for a much larger share of riders than peak-direction commuters. Of the inbound alighting riders who did not ride the bus, the greatest number (11 or 55%) walked away. Three riders were picked up by private autos, two drove away alone, and one was picked up by a taxi. One used another unspecified egress mode.

Mishawum

Mishawum Station on the Lowell Line originally opened in September 1984. (A previous station in about the same location had been discontinued many years earlier.) Service initially included stops by three outbound A.M. peak and four inbound P.M. peak Lowell trains. In 1989 one outbound A.M. peak Haverhill train also began serving Mishawum. In 1999 a Mishawum stop by one inbound P.M. peak Haverhill train was added. Other than the latter addition, inbound P.M. peak departure times at Mishawum changed little between 1984 and 2001. Outbound A.M. peak times changed several times, and were dictated more by operational considerations than by service considerations.

On April 30, 2001, a new station, Anderson/Woburn, opened about one mile further north on the Lowell Line. The new station has over four times as much commuter parking capacity as Mishawum, and was intended to replace that station. Most service to Mishawum was discontinued when Anderson/Woburn opened. For the benefit of reverse commuters walking to and from work locations closer to Mishawum, three of the four outbound A.M. peak trains and three of the five inbound P.M. peak trains that formerly stopped there continued to do so.

A July 1987 Ticket Audit showed 86 boardings for all trip purposes combined on the four inbound P.M. peak trains at Mishawum, including 78 on the three trips after 4:30. (This may have been overstated, as Audit figures are mostly likely to err on the side of being too high.) An October 1994 count showed 87 riders boarding the last three P.M. peak trains. Based on the responses to the 1993 survey, this would have included about 76 work-to-home trips, of which about 40 had final destinations in Boston.

Based on the distribution in the survey, of the 76 riders going home from work in the P.M. peak, 46 (61%) walked to the station. The next-largest group was 17 riders (22%) who were dropped off by private shuttle vans from the Lotus Development Corp. plant in North Reading. Three riders from other work locations were dropped off at Mishawum, possibly by co-workers. Three arrived by bicycle. The remainder provided insufficient information to identify their access modes.

A December 1996 CTPS count found only 68 riders boarding inbound P.M. peak trains at Mishawum. Outbound A.M. peak counts taken at the same time showed 86 passengers alighting at Mishawum from trains arriving between 6:30 and 9:30, with another six alighting from the train arriving at 6:14. These results imply that reverse commuting to Mishawum did not grow and may have declined between 1993 and 1996.

A December 2000 CTPS count found 81 riders alighting from the four outbound A.M. peak trains at Mishawum, and another nine from a train arriving at 6:09. Overall this was a slight decrease since 1996. Again trip purposes were not determined, but the 2000 counts did separate riders by means of egress from the station. The greatest number alighting from the four peak trains (59, or 73%) walked out of the station. Only 12 (15%) transferred to employer-sponsored shuttle vans, all of which were going to the

Genuity company in Burlington. (This differs from the situation at Route 128 Station, where the van service is jointly sponsored by several employers.) Genuity is also located at the outer end of MBTA express bus Route 354 from downtown Boston, which provides five outbound A.M. peak and five inbound P.M. peak trips.

The greatest number of van passengers from any one train at Mishawum was five. A total of five riders (6%) were picked up in taxis, and at least some of them had fare vouchers furnished by an employer in Wilmington. Three riders were picked up in private autos, and two transferred to Logan Express buses. The latter were presumably airline passengers, because fares would be prohibitively expensive for commuters. In any case, Logan Airport is far removed from Mishawum Station.

During the same time span, five inbound trains stopped at Mishawum, and a total of 24 passengers alighted from them there. Of these riders, 18 (75%) walked out of the station, or about the same proportion as among outbound alightings. Only one inbound rider (4%) transferred to a van. Two inbound riders were picked up in taxis, possibly using vouchers, and two others transferred to Logan Express buses. One rider was picked up by private auto. As at Route 128, these results indicate that connecting shuttle services must depend primarily on reverse commuters for ridership.

Wellesley Hills

A commuter rail station has existed at the Wellesley Hills Station site since 1834. The neighborhood around the station is characterized by small businesses, primarily retail establishments, but there are no individual large employers within convenient walking distance. At present, three outbound trains stop at Wellesley Hills in the A.M. peak. The Spring 2000 counts included two observations of alightings at Wellesley Hills from the first two outbound trains, but the third train was not observed there. The first train, due at 7:23, had 12 alightings on one day and nine on the other. The second train, due at 7:59, had 20 alightings on one day and 13 on the other. Trip purposes were not determined. The third train had fewer riders than either of the other two leaving Boston, so it probably also had fewer Wellesley Hills alightings than either of them.

Previous CTPS counts were done at Wellesley Hills in November 1994. Schedules of the first two trains differed only slightly from the present ones. The first train had 11 offs at Wellesley Hills and the second had 25. It was noted that most of the riders from the first train appeared to be going to work, but that at least nine of the 25 riders from the second train appeared to be students heading for high school. The 2000 counts indicate that reverse commuting work trips to Wellesley Hills are stable or declining slightly.

In November 2000, the Route 128 Area Business Council implemented a new shuttle route running from Wellesley Hills Station to several employers along Route 9 between Wellesley Hills and Route 128 and in Needham along Gould Street and in the New England Business Center. The Needham destinations are also served by the 128 Council's shuttle connection from Newton Highlands Station on the Green Line. The schedule of the Wellesley Hills shuttle was designed to serve passengers traveling to

and from points west of Wellesley Hills rather than reverse commuters. The three morning trips departed six to eight minutes after scheduled arrivals of inbound trains. The three P.M. peak trips were due at Wellesley Hills two to seven minutes before departures of outbound trains.

Ridership figures for the Wellesley Hills shuttle were available only for November 2000 when information was being gathered for this study. Excluding Thanksgiving week, ridership totaled only 17 to 19 passengers per week, or an average of fewer than four riders per day. It would not be expected that in the first month of operation the shuttle would have attracted significant numbers of new employees to work at any of the sites served. Ridership never reached satisfactory levels, however, and the route was discontinued in May 2001.

It is unclear how well the existence of this service was made known to potential users. The Newton Highlands - Needham shuttle which started in 1999 was still showing growing ridership during 2000. In January ridership was typically around 26 each way per day. By November it had grown to about 36.

South Acton

A commuter rail station has existed at South Acton since 1844. The present station replaced the original station, on the opposite side of Route 27, in 1977. The area around the station is mostly residential, with no major individual employers within convenient walking distance. A private shuttle bus service was started about 1999 to connect South Acton Station with the Clock Tower Place office complex in Maynard, two miles away. Present commuter rail trains at times suitable for reverse commuting include outbound trains due at South Acton at 8:20, 9:15, and 9:34 a.m., and inbound trains leaving there at 3:40, 4:17, 5:07, and 6:40 p.m.

A January 2001 CTPS count found a total of 34 passengers alighting at South Acton from the three outbound A.M. trains listed above. Of these riders, 19 (56%) transferred to the Clock Tower Place bus and 12 (35%) were picked up in private autos. Two walked away from the station, and one drove away in a car that had been parked there. The first outbound train, due at 8:20 a.m. had the heaviest total alightings (21) and bus transfers (10). The train arriving at 9:15 had 11 offs, including seven bus transfers. The train due at 9:34 had only two offs, both bus transfers. This pattern is consistent with the assumption in this study that most reverse commuters need to arrive at work before 9:30 a.m.

Boarding points of these passengers were not determined. According to the bus sponsors, the service was used by a two-way total of about 45 riders a day in December 2000, and most of the riders were believed to have come from suburban origins rather than from Boston. The 19 passengers observed transferring to the bus were presumably going to work. Some of the 14 who used other egress modes may also have been going to work, but some were probably returning home from night-shift jobs or making non-work trips.

The January 2001 count also showed a total of six inbound alightings from the three trains scheduled to arrive at South Acton from Fitchburg between 6:30 and 8:00 a.m., and two more from a train due at 6:21. Alightings were heaviest (4) from the train due at 7:58, including three bus transfers. This was the last inbound train from west of South Acton until 11:02 a.m.

South Acton Station is at the approximate mid-point of the Fitchburg Line, at 25.3 miles from Boston and 24.3 miles from Fitchburg. The above-average route length provides an unusually large number of opportunities for interzone travel to South Acton both from stations further outbound and from stations further inbound. The Fitchburg Line is also the only commuter rail line to stop directly in Cambridge as well as in Boston. Despite these advantages as well as dedicated connecting bus service to the largest employment area served by the station, relatively small numbers of work trips are made by riding commuter rail to South Acton from either direction.

APPENDIX A - FURTHER DETAILS ON OPERATIONAL ISSUES

Chapter 2 of this report discusses some of the operational constraints that would affect the ability to increase frequency of reverse commuting service on MBTA commuter rail lines. This appendix examines these constraints in greater detail.

Single-Track Constraints

As noted in chapter 2, most of the MBTA commuter rail lines have some single-track segments. These were taken into account in the analysis of potential reverse commuting schedules in chapter 4, but they were not all described specifically there. Such information may be of use to others in the event that suggestions for other service expansions are made. The single-track segments are as follows:

Newburyport/Rockport Line:

From McNall (0.5 mi. south of Salem Station) to Northey Point (0.2 miles north of Salem Station).

From Chesley (0.7 miles north of North Beverly) to Newburyport, except for passing track south of Ipswich Station.

From Wilson (0.3 miles south of Gloucester Station) to Rockport Station.

Haverhill/Reading Line

From Reading Junction (1.8 mi. north of North Station) to Fells (0.5 miles south of Wyoming Station).

From Ash Street (0.3 mi. south of Reading Station) to Andover Street (0.4 miles south of Lawrence Station).

Lowell Line

None

Wildcat Branch (connection from Lowell Line to Haverhill/Reading Line)

From Wilmington Station to Wilmington Junction

Fitchburg Line

Through Waltham Station.

From 0.2 mi. west of South Acton to Willows (2.3 miles west of Ayer).

Framingham/Worcester Line

From CP-3 (1.9 mi. west of Back Bay) to CP4 (3.6 mi. west of Back Bay).

Trains stopping at Newtonville, West Newton, or Auburndale in either direction must use Track 2 between CP-4 and CP-11 (1.2 mi. west of Auburndale) because of platform configuration. Trains stopping at Yawkey in either direction must use Track 2 between Cove (0.1 mi. east of Back Bay) and CP-3 because of platform configuration.

Needham Line

From Dale (0.8 mi. west of Forest Hills) to Needham Heights, except for passing sidings: from 0.4 to 0.8 mi. west of West Roxbury Station, and from 0.4 to 0.1 mi. east of Needham Junction Station.

Franklin Line

From connection with Attleboro/Stoughton Line at Read (0.4 mi. north of Readville Station) to Sprague (0.2 mi. south of Readville).

From Norwood Central to Forge Park, except for passing siding from Walpole Station to 0.7 mi. south. Trains can also clear main line at layover facility 0.1 mi. north of Franklin Station.

Attleboro Line

No single track sections. Trains stopping at Ruggles in either direction must use Track 1 or Track 3 between Cove (0.1 mi. east of Back Bay) and Plains (2.2 mi. south of Ruggles).

Stoughton Line

From just south of Canton Junction Station to Stoughton Station.

Fairmount Line

Through Readville station, including connections to Franklin and Attleboro/Stoughton lines.

Old Colony Lines (shared track)

From Fly (1.3 mi. south of South Station) to Vic (3.9 mi. south of South Station).
From Squant (3.1 mi. south of South Station) to Braintree Station.

Middleborough/Lakeville Line

From Braintree Station to Middleborough/Lakeville Station is all single track, except for passing sidings: from 1.2 to 0.1 mi. north of Holbrook/Randolph Station; from 0.5 mi. north of Montello Station to 0.8 mi. south of Brockton Station; from Westdale (2.7 mi. south of Campello Station) to Stanley (2.1 mi. north of Bridgewater Station); and From Mid to Pilgrim (1.7 mi. to 0.8 mi. north of Middleborough/Lakeville).

Plymouth/Kingston Line

From Braintree Station to Seaside (Junction of Kingston and Plymouth branches) and from Seaside to Plymouth, is all single track, except for passing sidings: from just south of South Weymouth Station to 1.5 mi. north of Abington Station; from Golf (1.5 mi. south of Whitman Station) to Bryant (1.0 mi. north of Hanson Station; and from Burrage to Oak (0.3 mi. north of Halifax Station to 1.0 mi. south).

Rolling Stock Shortage

The maximum expansion of reverse commuting service discussed in chapter 4 would require a total of five more commuter rail equipment sets than are now in the MBTA fleet. These would be relatively poorly utilized. Because of round trip running times, each set would be able to make no more than one round trip in each peak period. The schedules of the reverse commuting trips for which these trains would be required would not allow them to also be used to add peak-direction trains in the same peak.

Two of the new North Side sets would be needed for reverse commuting service only in the P.M. peak. In the A.M. peak they could be used to expand peak-direction service. One of the new South Side sets would be needed for reverse commuting service only in the A.M. peak. In the P.M. peak it could be used to expand peak-direction service.

Load factors on all reverse commuting trains would be much lower than those on most peak-direction peak-period trains now. Because of the high capital cost of rolling stock and limited funds, the MBTA must give priority to allocating new equipment to where it is most needed. Assigning new train sets in the manner discussed in chapter 4 would be inconsistent with this.

Constraints at North and South Station

In both peak periods, reverse commuting trains that would be added under the schedules discussed in chapter 4 would not be at either North Station or South Station at the times when track occupancy currently peaks. Therefore, it does not appear that the stations themselves would place any limitations on this service.

Maintenance Facilities

The expanded reverse commuting schedules discussed in chapter 4 could present some problems in finding locations to store additional train sets needed for the service when they were not in use. On the North Side, under the maximum expansion strategy, one train set each would be added to the Newburyport, Haverhill/Reading, and Fitchburg Lines. The cost calculations in chapter 4 are based on an assumption that all three sets would be kept in Boston at night. In addition, one set now kept at Bradford on the Haverhill Line at night would be moved to Boston.

At present, four train sets are kept in Boston at night, but during the midday up to 10 sets at once are at the Boston maintenance and servicing facility. Increasing the nighttime assignment of sets from four to eight should not cause a capacity problem unless the extra equipment was in the way of shifting other sets around for servicing. It would also be possible to leave some trains in North Station overnight, but this would be less desirable from a security standpoint.

During midday, the three new trainsets would all be in Boston along with present equipment, and this could result in some congestion. Moving the extra trains out to remote layover points during midday would increase operating costs from those shown in chapter 4.

On the South Side, under the maximum expansion strategy, one train set each would be added to the Franklin and Providence lines. In addition, one set now kept at Worcester and one set now kept at Needham Heights at night would be transferred to Boston.

At present, 11 train sets are kept at the Southampton Street facility in Boston at night. During midday up to 16 sets at once are at Southampton Street. Another eight sets are sent out to Readville in non-revenue service because of insufficient capacity at Southampton Street. Adding four sets at night would not exceed the present midday occupancy of Southampton Street, but might interfere with shifting other sets around for maintenance. In addition, there may be more Amtrak intercity train sets using shared facilities on the South Side at night than during the midday.

The cost calculations in chapter 4 assume that during the day the extra Providence set would be kept at the new layover facility being built near the outer end of the route. There would be capacity for it there, because the trains kept there at night would be out on the line or in Boston. The cost calculations assume that the extra set for the Franklin Line would be in Boston during the day, but it would also be possible to leave it at Franklin. This would reduce the extra operating cost, as it would eliminate one added inbound mid-morning trip. The Franklin facility would have capacity for this set at midday because the trains kept there at night would be out on the line or in Boston.

Potential Conflicts with Freight Operations

On many of the lines used for MBTA commuter rail service, there is little or no freight service. On those lines, freight operations are usually already restricted to midday or late night to avoid conflicts with peak commuter service. Addition of reverse commuting trains would not conflict with freight operations. Lines that do carry heavy freight traffic are the Framingham/Worcester Line, the segment of the Fitchburg Line west of Willows in Ayer, and the segment of the Haverhill/Reading Line north of Lowell Junction in Andover.

The Framingham/Worcester Line is the east end of the CSX Boston Line, and is the most heavily used rail freight corridor in New England. Freight trains terminate at yards near Framingham station and in Allston. Many of them originate at points in the midwest, and their schedules are determined in part by those of connecting trains. At present, most of them run through commuting territory outside of peak commuting hours, but there are some exceptions. Much of the line is owned by CSX rather than by the MBTA, and CSX is responsible for dispatching all the trains

on it. Increases in passenger service on this line must be negotiated between the MBTA and CSX.

The west end of the Fitchburg Line and the north end of the Haverhill/Reading Line are both part of the Guilford Rail System Freight Main Line. (They are linked by lines used exclusively for freight service between Willows and Lowell Junction.) As in the case of the Framingham/Worcester Line, schedules of freight trains on the Freight Main Line are determined in part by those of connecting trains at points far removed from Boston. Most of them run through commuting territory outside of peak commuting hours, but there are some exceptions. The segments of the Freight Main Line used for passenger service are owned by the MBTA, but Guilford has rights retained by the predecessor company at the time of the sale of the lines to the MBTA. Guilford is also responsible for dispatching trains on those segments.

APPENDIX B - FURTHER DISCUSSION OF POTENTIAL DEMAND FOR COMMUTER RAIL REVERSE COMMUTING SERVICE

Chapter 2 of this report includes an analysis of the potential demand for commuter rail reverse commuting service under present conditions. This appendix examines additional factors not explicitly included in the chapter 2 analysis that might affect ridership volume. The conclusion is that within the bounds of assumptions that can reasonably be made at this time, these additional factors would not lead to significantly greater ridership totals than those estimated in chapter 2. The time frame that would be needed for implementation of reverse commuting service would be sufficiently short that deferring it now would not preclude future implementation if actual changes in travel patterns indicated that such service was justified.

Impact of Projected Land Use Changes on Reverse Commuting From Boston

Data Sources

The Massachusetts Division of Employment and Training (DET) collects year-by-year reports of the number of people employed within each city and town in Massachusetts, and of the number of residents of each city and town who are employed anywhere, but these do not include cross-tabulations of community of residence by community of employment. The DET figures have been used by the Metropolitan Area Planning Council (MAPC) as a base for projections of employment for each of 164 cities and towns in the Eastern Massachusetts Regional Planning Project (EMRPP) Area at five-year intervals from 2000 to 2025. Projections of total population changes in each of these communities have also been made. Like the DET reports, however, the MAPC projections do not include cross-tabulations of community of residence by community of employment.

The most comprehensive figures on employment by city or town with breakdowns by city or town of residence are provided by the Journey-to-Work reports in the decennial U.S. Censuses. The most recent Census was conducted in 2000, but because of the vast amount of data processing required, the Journey-to-Work reports are not expected to be released by the Census Bureau until some time in 2002. Until then, the most recent figures will be those from the 1990 Census.

Potential Changes in Employment Locations of Boston Residents

Because of substantial development of new suburban office and industrial complexes since 1990, there has been concern among proponents of improved reverse commuting service that available data do not adequately reflect growth in demand for work travel from Boston to outlying cities and towns. Lacking actual data on present reverse commuting by Boston residents, it is necessary to estimate changes in Boston work trips to each city or town based on one of the three following assumptions:

- 1) Boston work trips to the city or town are increasing at a faster rate than total employment in that city or town.
- 2) Boston work trips to the city or town are increasing at the same rate as total employment in that city or town.
- 3) Boston work trips to the city or town are increasing at a slower rate than total employment in that city or town.

The first method would imply that the jobs available in the particular community are, on average, more attractive to Boston residents than to people living elsewhere. This may be true in isolated cases, especially where a major employer has recently relocated from Boston to a suburban location, but in general, attractiveness of jobs would be expected to decline as distance from home to work location increased. Employment of Boston residents in a given city or town could also increase at a faster rate than total jobs if the Boston labor force were growing at a faster rate than employment opportunities in Boston and adjoining communities, but as discussed below, this is not the case.

The second method would imply that the jobs available in the particular community are, on average, equally attractive to Boston residents as to people living anywhere else. While this method would produce more reasonable results than the first one, it again fails to take into account the effect of increasing travel distance and time on attractiveness.

It appears, then, that the most accurate estimates of future Boston employment in most cities and towns would be obtained by the third method, assuming that the rate of increase from 1990 will be less than the rate of increase of total jobs in that locality. The estimates in Tables 2-1 and 2-2 used the second method, so it is more probable that they overstate rather than understate ridership potential under present conditions. Further support for this conclusion is provided in the following subsection.

Distribution of Employment Locations of Boston Residents in 1990

According to the 1990 Census Journey-to-Work reports, 98.7% of Boston residents who were employed at that time had work locations somewhere within the 164 EMRPP cities and towns. The city of Boston itself accounted for the largest share, at 68.5%. Cities and towns other than Boston with MBTA rapid transit or light rail service were next, at 14.9%. EMRPP cities and towns that currently have commuter rail service in operation or under construction, but are not also served by rapid transit or light rail, were the third most important group, at 10.5%. (The opening of the Worcester, Old Colony, and Newburyport commuter rail extensions since 1990 has increased the possibilities for reverse commuting, but passenger counts show that actual ridership is too low to change the percentages stated above.)

EMRPP cities and towns that currently have no rapid transit, commuter rail, or light rail service in operation or under construction provided jobs for 4.9% of all Boston workers in 1990. Of these, the greatest number (2.8%) were in locations that would have better access via express bus service from downtown Boston or feeder bus service from existing rapid transit lines than via connections from any existing or proposed commuter rail lines. Cities or towns that would have stations on the Greenbush or Fall River / New Bedford commuter rail extensions accounted for 0.3%. The other 1.8% were in locations that would be closer to existing or proposed commuter rail stations than to rapid transit stations, but even some of them could be better served by express bus service from Boston.

Projected Changes in Employment to 2000

According to MAPC figures, total employment in the EMRPP area was expected to increase by 8.8% (188,070 jobs) between 1990 and 2000. In the same time span, MAPC had predicted an increase of 3.6% in total Boston population. DET figures show that between 1990 and 1999 (the most recent year for which figures are available at this writing) actual employment in the EMRPP area increased by 9.4%. Consequently, total employment in the area in 1999 was 0.6% higher than the MAPC projection for the following year.

Changes in employment in individual cities and towns do not occur at steady rates. Employment levels are often subject to some fluctuation, as major employers move in or out of a community. Ten-year growth may be distributed over several years, or may occur in a few large spikes corresponding with events such as opening of a new office complex. With absolute gains distributed uniformly over a ten-year interval, it would be expected that 90% of ten-year growth would have occurred at the end of nine years. With employment growing at a constant percentage rate, however, with an increase of 8.8% at the end of ten years, 99.2% would occur by the end of the ninth year. Therefore, actual EMRPP employment in 1999 was 1.4% higher than the interpolated result of the MAPC forecasts for the same year.

Preliminary Census figures indicate that between 1990 and 2000 Boston population increased by 2.6%, resulting in a total 1.0% lower than the MAPC projection. DET figures indicate that between 1990 and 2000 the number of Boston residents employed anywhere decreased by 1.2% (3,583). From 1990 to 1999, the total number of jobs within the city of Boston increased by 6.9% (37,156). These population and employment trends further support a conclusion that the number of Boston residents employed in most cities and towns outside Boston would have increased at a slower rate than total employment in those localities between 1990 and 2000, and may have decreased.

Projected Changes in Employment to 2020

For the EMRPP area as a whole, the MAPC projected employment increase from 1990 to 2020 is 577,462 jobs (27.0%). Employment within the city of Boston alone is projected

to increase by 123,566 (23.0%). For the rest of the area the projected increase is 453,896 (28.3%). In the same time span, total Boston population is projected to increase by 9.9% (57,026). DET figures for 2000 show that the ratio of employed Boston residents to total Boston population that year was 48.2%. (The 51.8% of the population not employed includes children, retirees, homemakers, etc. as well as unemployed job-seekers.) With the same labor force participation rate as in 2000, the projected population increase by 2020 would result in an increase of 27,470 Boston residents working anywhere. In order for the number of Boston residents employed outside Boston to increase at the same rate as total employment in the remainder of the EMRPP area, it would be necessary either for the number of Boston residents employed in Boston to decrease, or for the labor force participation rate to increase by about 20%. Between 1990 and 2000, the number of employed Boston residents relative to Boston population decreased by 3.7%, so a 20% increase in the labor force participation rate over the next 20 years is improbable.

In Tables B-1 and B-2, unconstrained estimates of changes in employment of Boston residents have been produced by assuming that in each city or town the rate of change in that number will be the same as the rate of change in total employment. Constrained estimates have been produced by factoring down the unconstrained estimates uniformly to limit the overall rate of growth in employment of Boston residents to the rate of growth in total Boston population. These estimates do not explicitly take into account the effect of travel time and distance on relative attractiveness of work locations. To some extent this is reflected in the percentage of total jobs in each city or town that were held by Boston residents in 1990, but subsequent changes in housing availability could affect the relative attractiveness of jobs for workers from each origin.

Despite above-average gains in total employment in some suburban employment centers, the share of employment of Boston residents accounted for by each sub-group of cities and towns is likely to change little between 1990 and 2020, because the absolute numbers of Boston residents employed in the fastest-growing communities will remain relatively low. The ridership estimates for 1999 travel levels in Tables 2-1 and 2-2 were not constrained by projected population changes in the city of Boston. When these are taken into account, estimates for reverse commuting by rail in the year 2020 would not differ appreciably from those shown for 1999 in Tables 2-1 and 2-2. It should be reiterated that the commuter rail shares of reverse commuting traffic in those tables were based on a presumption that extensive feeder service connections would be provided to link suburban rail stations with employment locations. Without such connections, rail shares would be much lower, because in most cases suburban employment areas are beyond walking distance from stations.

Latent Demand Assessment Method

In estimating the demand for a new transportation service, it is usually much easier to predict the number of people who would shift to that service from some other means of transportation than the number who would begin making new trips as a result of the

new service. Those making new trips presumably either have no other means of making the same trip, or no other means that they are willing to use. The latter category would include people who have automobiles available but find them too inconvenient for the trip in question. For most reverse commuting trips, commuter rail service would be unable to match the door-to-door convenience and travel time of driving alone. Therefore, it is reasonable to assume that most of the new trip makers on new reverse commuting trains would not have autos available for the same trips.

Experience from the Old Colony commuter rail service restoration provides some data on the extent to which a new transit service generates new trip making. A survey conducted at the end of the first year of Old Colony operation found that 16% of all of the passengers riding from home to work on Old Colony trains had not previously made the same trips. The survey did not determine to what extent making a new trip was a direct result of Old Colony service having been started, and to what extent it was coincidental for reasons such as a change in home or work location, or new entry into the workforce. The vast majority of passengers making new trips indicated that they had automobiles available for those trips. This implies that if there had been no Old Colony service, they would still have begun making these trips.

A more accurate measure of demand induced by new service would be the ratio of riders who did not make the same trip before and do not have autos available to riders who did make the same trip before. To account for differences in base-case transit alternatives between the present Old Colony service area and areas that could have expanded reverse commuting service, a more comparable measure of induced demand would be the ratio of riders who did not make the same trip before and do not have autos available to riders who did make the same trip before and have autos available. On the two Old Colony lines, the average for this measure was 2.6%.

Prior to the start of Old Colony service, 67% of Old Colony riders who made trips before used some other form of public transportation for all or part of the trip. Some did so by choice and others by necessity. As shown in Table 3-1, the majority of MBTA commuter rail stations already have at least some service at times suitable for reverse commuting from Boston. Some that do not are in residential areas with few or no work destinations nearby. The study excluded communities with rapid transit service, but some of the others have MBTA feeder or express bus service.

A further adjustment would be required for differences in overall automobile availability. On the Old Colony lines, 91% of the passengers making home-to-work trips, including both new and diverted trips, reported that they had autos available for the same trips. The lowest reported rate was among passengers boarding at Brockton Station, at 66%. Auto ownership rates vary among Boston neighborhoods. In the 1993 commuter rail survey, the overall rate of auto availability among passengers making home-to-work trips from homes within Boston was 75.7%, ranging from a low of 45.1% at Uphams Corner on the Fairmount Line to 88.4% at Highland on the Needham Line.

In Tables 2-1 and 2-2, the estimated ridership for maximum reverse commuting service at present travel levels was 3,771 riders a day, including only diversions of trips that would be made otherwise. As shown in Table 2-2, this would include 1,509 trips currently made by commuter rail, so 2,261 would be made by other means. This would include driving and use of MBTA express or feeder buses. Based on the distribution of destinations, the present transit alternatives serving them, and 1990 Census figures, at least half of the trips not already being made by commuter rail would be diverted from some other form of transit. An equal split between transit and auto would make 1,130 each. All of those who now drive can be assumed to have autos available. If the same Boston auto availability rate found in the 1993 survey is applied to present commuter rail and other transit users, the total of riders with autos available becomes $1,130 + .757 \times (1,130 + 1,509) = 3,127$.

This would be equivalent to 82.9% of the predicted 3,771 riders. If it is assumed that induced ridership would consist entirely of people without autos available, and that they would be attracted in such numbers as to bring the overall average auto availability down to 75.7% again, then the total becomes $3,127 / .757 = 4,132$, or an additional 361 above the estimated 3,771. This would be an add-on of 9.6%. A larger share of diversions of transit users, or a lower auto availability rate among them, would lower the overall average auto availability rate among diverted riders, requiring an even smaller level of induced demand to reach the 75.7% average.

The induced demand calculations above indicate the number of riders who would not travel between the same origin and destination pairs in the absence of commuter rail reverse commuting service improvements. They do not all represent people who would otherwise be unemployed; some would merely be diverted from other work locations.

In conclusion, based on the best available information, and reasonable assumptions, the number of new reverse commuting trips generated by expanded commuter rail reverse commuting service is likely to be small compared with the number of trips that would be made otherwise by some other means.

Importance of Reverse Commuting Demand to Retail Centers or Schools

The ridership estimates in Tables 2-1 and 2-2 were based only on travel from homes in Boston to work locations in outlying cities and towns on commuter rail lines. This was done because the primary focus of the study was to determine the extent to which improvements in reverse commuting service would attract work trips to suburbs by Boston residents. Trips for other purposes such as to schools or retail centers would generate some additional revenue, but the amount would be insufficient to alter the viability of the service. There is no comprehensive database on non-work trips comparable to the Census Journey-to-Work reports, but MBTA passenger surveys provide some information on non-work travel.

Traffic to Retail Centers

Retail businesses in suburban shopping centers typically open for customers at times later than when factory or office workers begin their shifts, so outbound A.M. peak trains would be of limited use to shoppers. Store employees reporting for work ahead of opening time would already be counted in work trip totals.

The present commuter rail system attracts few shopping trips. In the 1993 survey trips from home to shopping or shopping to home accounted for under 1.5% of the ridership on every line except the Fairmount Line, where the share was 3.6%. On the Old Colony lines in 1998, shopping trips accounted for 0.2% and 0.8% of all riders.

Aside from the inconvenience of transporting purchases on a train, there is little incentive to use commuter rail for shopping trips. Past commuter rail surveys mostly reflect travel by suburban residents. Most merchandise that they could purchase in downtown Boston could also be found at suburban retail centers, and most suburban commuter rail riders have cars available, at least some of the time, which they can use for shopping trips. There is also little reason for Boston residents to take commuter rail to suburban retail centers, because the same merchandise is available in or closer to Boston. Commuter rail fares would at least partly offset savings in suburban prices. Because they are designed for convenient auto access, suburban shopping malls are located along major highways, and few are near commuter rail stations. Therefore, additional feeder services would be needed to attract shoppers.

School Traffic

School traffic on commuter rail is generated mostly by colleges and private secondary schools. Public school students generally make trips too short to involve use of commuter rail. Private schools typically attract students from scattered origins, and often have their own networks of buses, vans, and carpools. Only a small percentage of the students at any one school would be approaching from a direction from which commuter rail would be convenient. Except in cases of schools located close to rail stations, connecting transportation from stations to schools would need to be provided.

Some observations of reverse commuting traffic to schools and colleges have been made by CTPS in conjunction with various projects. The best example of reverse commuting to a college was found in 1994 at Brandeis/Roberts Station on the Fitchburg Line in Waltham. This station is on the edge of the Brandeis University campus. The trains make an intermediate stop at Porter Square in Cambridge, in an area with a large student population. Three outbound trains stopped at Brandeis/Roberts in the A.M. peak. A total of 94 passengers alighted from them and walked toward the campus, but this figure included some people going to work at or near the university in addition to students.

There are few other examples of colleges located as close to a commuter rail station that has service from a major student residential area. On the Middleborough/ Lakeville

Old Colony branch, two outbound A.M. peak trains stop at Bridgewater Station, near Bridgewater State College. Passenger counts there in October 1998 showed 10 passengers alighting from the train due at 7:14 and 16 from the train due at 9:05, but trip purposes were not determined. The station had been open for only one year at the time. It is unknown whether student enrollment in subsequent classes has included significantly more commuter rail users.

A branch of North Shore Community College adjoins Lynn Station on the Newburyport/Rockport Line. A November 2000 count showed a total of 46 passengers alighting from the four outbound A.M. peak trains stopping there, but it was not determined whether any of them were students going to the college.

On the Franklin Line, Franklin/Dean College Station is located a few blocks from the Dean College Campus. One outbound train arrives at this station in the A.M. peak, at 8:45. CTPS Passenger counts have not been done there. An April 2000 count showed 37 passengers boarding this train at South Station, with 25 still on board after the first stop at Dedham Corporate Center. There were five other stops in addition to Franklin/Dean College, however, and passengers alighting at Franklin/Dean were not necessarily all students.

At the secondary school level, the heaviest observed commuter rail ridership was at West Roxbury Station on the Needham Line. West Roxbury High School and Roxbury Latin School are both within walking distance of the station. In an October 1994 count, 37 students were observed alighting from an outbound train due at 7:26 A.M. and eight more from a train due at 7:42. The next train, due at 8:51, was not observed, but would have been too late for most students.

The second-heaviest observed reverse commuting to a secondary school was at Kendal Green Station on the Fitchburg Line in Weston, in November 1994. The first outbound train, due there at 7:55 A.M., had 23 alighting students who transferred to vans going to the Cambridge School, about one half mile away. The second train, at 8:50, had no students alighting there.

Another station on the Fitchburg Line that is known to serve reverse commuting students is Concord, located about one half mile from Concord Academy. CTPS has not done counts there. In a Spring 2000 count, the one outbound A.M. train that arrives at Concord in time for school traffic had a total of 124 passengers on board leaving Porter Square, but only 76 of them were traveling past Waltham Station. There were five other possible alighting stations in addition to Concord, including Brandeis/Roberts and Kendal Green, so the number of students going from North Station or Porter Square to Concord Academy would have been fairly low.

No other commuter rail stations where CTPS counts have been done have had sufficiently large numbers of reverse commuting students to be noteworthy. In conclusion, the potential for student traffic is limited to a few stations within convenient distance of college or secondary school campuses. Many, if not most, of

these already have service at the times most needed by students. Therefore, expanded reverse commuting schedules designed to serve work trips would attract few students who are not already using trains.

Potential Reverse Commuting Ridership from Origins Outside Boston

The legislation under which this study was performed specified that it was to examine the demand for additional reverse commuting service from the city of Boston. The legislation did not preclude consideration of demand from other origins, but for reasons set forth below, it was decided that the level of ridership likely to be predicted from an analysis of travel from other origins would be too small to justify the amount of resources that would need to be devoted to that task.

On the MBTA commuter rail system interzone trips are defined as those that do not begin, end, or pass through one of the downtown Boston stations or other stations in fare Zones 1A or 1B. Passenger counts and revenue data show that interzone travel accounts for only a small percentage of total ridership, and most reverse commuters with origins outside Boston would be in subgroups of the interzone riders. In addition, some reverse commuters from outside Boston could board at stations in Zone 1B, and some could travel to downtown Boston stations from points outside Boston and then complete their trips via commuter rail.

At present, all Zone 1A and 1B stations on South Side commuter rail lines are within the city of Boston, and are too far from the city limits to attract riders from origins outside Boston. Therefore, reverse commuting ridership from these stations is already taken into account in the forecasts for Boston origins. There are no Zone 1A stations on North Side lines, but there are four Zone 1B stations. These are Chelsea, Malden Center, West Medford, and Porter Square, which are discussed below.

Interzone Trips

Very limited information is available about interzone ridership. A daily interzone rider would reduce fare expense by 20% to 25% by using a monthly interzone pass instead of single-ride tickets. (There are no multiple-ride interzone tickets.) Therefore, it would be expected that reverse commuters whose usual trips to work included interzone commuter rail segments would use interzone passes. An Amtrak revenue report from January 1999 shows total sales of only 88 interzone passes for use on North Side Lines and only 48 for use on South Side Lines. The North Side total was a decline from 106 reported in October 1994, but the South Side total was an increase from the 17 reported then. The South Side increase was partly a result of new interzone travel possibilities created by the Worcester and Old Colony extensions.

Single-ride interzone tickets are sold only on board trains, and sales are not reported separately from those of other forms of tickets sold on board. A CTPS examination of one-day receipts from on-board sales in October 1994 showed a total of about 525 each way on North Side lines and 175 each way on South Side lines. If sales of these have

followed a pattern similar to that of interzone pass sales, it would be expected that North Side sales would have decreased and South Side sales increased compared with these totals. Interzone trips would include non-work trips and work trips to destinations outside Boston from homes further out on routes as well as reverse commuting trips. The high use rate of single-ride fares compared with passes implies that the majority of interzone trips are either non-work trips or trips by passengers who do not use the train every workday.

In 1993, interzone trips for all purposes accounted for about 5% of the ridership on North Side lines and for about 1% on South Side Lines. The 1998 Old Colony survey found an unusually high proportion of interzone ridership (6.9%) but reverse commuting home-to-work trips accounted for under 0.1% of the total.

Trips to and from Zone 1B

Most Zone 1B stations outside Boston generate little reverse commuting traffic. A January 1999 count at Chelsea Station showed only 15 outbound A.M. peak boardings and 14 inbound P.M. peak alightings for all trip purposes there. An April 2000 count at Malden Center found only 17 outbound A.M. peak boardings and 22 inbound P.M. peak alightings for all trip purposes there. Some of these riders may have transferred to or from the Orange Line or buses rather than originating in Malden itself. A May 2000 count at West Medford found 28 outbound A.M. peak boardings and 18 inbound P.M. peak alightings for all trip purposes there.

Porter Square Station on the Fitchburg Line has the highest apparent level of reverse commuting traffic of any of the Zone 1B stations. A January 1999 count there showed a total of 205 outbound A.M. peak boardings and 153 inbound P.M. peak alightings for all trip purposes there. These were similar to the total boardings and alighting for the same trains at North Station, implying that Cambridge would be almost as large a source of reverse commuters as Boston. Some of the Porter ridership consists of transfers to or from the Red Line, however, and this includes some Boston passengers.

Destinations in Waltham or Concord would account for 85% of the ridership predicted for the Fitchburg Line in chapter 2, but both communities already have the minimum standard three outbound A.M. peak and three inbound P.M. peak trains called for in the study. Potential service improvements discussed in chapter 4 would allow reverse commuting to stations between South Acton and Fitchburg, but would not increase service frequency at Waltham or Concord. Therefore, the omission of Porter Square boardings mostly leaves out riders who would be expected to use the system regardless of whether or not the chapter 4 changes were implemented. Table 2 shows a predicted total of 48 reverse commuters a day from Boston to stations west of South Acton. Additional ridership from Cambridge would at best be about equal to this.

Trips Through Boston

Trips involving travel through Boston between origins and destinations both outside Boston account for only a small percentage of commuter rail riders. In the Old Colony survey, only 2.5% of all riders had trips requiring them to pass through Boston to points other than Cambridge, and only 0.5% were traveling between a work location on the Old Colony Lines and a home beyond Boston or Cambridge. The 1993 survey yielded similar results. Riders who traveled from home to Boston and then continued to work by commuter rail accounted for 0.6% of all trips, with the proportion on individual lines ranging from 0.2% to 0.8%, and exceeding 1.0% only on the Lowell Line. The high percentage on the Lowell Line was largely a result of reverse commuting trips to Mishawum Station.

In conclusion, addition of reverse commuting trips by passengers who would have to travel into Boston to board the trains going nearest to their work destinations would not significantly increase the ridership estimates in chapters 2 and 4.

Reasons for Limited use of Commuter Rail for Non-Boston Travel

All MBTA commuter rail lines have either North Station or South Station in Boston as the inner terminal. Therefore, passengers can reach Boston Proper from any outlying station without transferring, although some have to use other modes to complete their trips after arriving in Boston. Of the 164 cities and towns in the Eastern Mass. Regional Planning Project (EMRPP) area, Boston is by far the location of the largest share of jobs. As of 1999, 24.6% of all jobs in the EMRPP area were located in Boston. Despite growth of suburban employment, the Boston share was only slightly lower than the 25.1% in 1990. Cambridge was a distant second, with 4.8% of EMRPP jobs in 1999. No other individual communities accounted for over 3%, and only 15 had between 1% and 3% each.

Residents of a given city or town who are employed somewhere other than Boston are most likely to be employed in the community where they live or in an adjoining one. Of the 163 EMRPP communities other than Boston, 70 (43%) currently have direct commuter rail service in operation or have stations under construction. Another six (4%) would have direct service on routes that are likely to open within the next five years. For a city or town among the 53% without direct commuter rail service, that mode is not a possible alternative for travel to work either in the same municipality or one directly adjoining it. Depending on home and work locations, commuter rail may or may not be a practical alternative for a portion of longer work trips.

Of the 70 EMRPP communities with rail service, 42 (60%) have only one station. In such cases, rail cannot be used for travel entirely within the same community. It can be used for travel to other communities along the same route, but commuters do not necessarily have home and work locations that are both served by the same rail line. Travel possibilities are increased by riding into Boston on one commuter rail line and out to a final destination on another commuter rail or other transit line, but this often

requires a much longer trip in both time and mileage than driving from origin to destination would. Arrivals and departures of trains on different lines at the Boston stations are based on considerations other than connections among them, so transfers often require inconveniently long waiting times. Transfers between North Side and South Side lines currently require an intermediate transit link or a long walk.

In most communities with rail stations, the majority of residents live beyond walking distance of the nearest station, and require some other form of transportation for access to the station. At the destination end, many work locations are beyond walking distance from stations, and require shuttle vans or taxis for access. Commuters who could drive to a boarding station could also drive all the way from home to work. At most commuter rail parking lots there is a fee, and many fill to capacity each day. In contrast, most work locations have ample free parking. Headways on commuter rail lines are relatively long, limiting flexibility in arrival and departure times at work locations.

As the combined result of factors cited above, very few commuters traveling between homes and work locations that are both outside of Boston have the ability or the incentive to make use of commuter rail for their trips. Increasing the frequency of trains at times suitable for reverse commuting from Boston, as discussed in chapter 4, would also facilitate reverse commuting by some suburban residents, but would not eliminate most of the obstacles. Therefore, suburban-based ridership would not add significantly to the demand estimates in chapter 2.

Table B-1 - Projected Employment of Boston Residents by EMRPP City or Town
(Unconstrained by Boston Population Growth)

Employment Location	1990 Employment		2000 Employment (est.)		2010 Employment (est.)		2020 Employment (est.)	
	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.
CITY OF BOSTON	537,664	189,171	565,086	198,819	612,474	215,492	661,230	232,646
Rapid Transit Service Area								
CAMBRIDGE	103,278	16,039	114,144	17,726	124,536	19,340	137,245	21,314
NEWTON	44,793	7,300	47,768	7,785	49,751	8,108	52,062	8,485
BROOKLINE	18,123	5,395	17,506	5,211	18,342	5,460	18,972	5,648
QUINCY	39,938	4,371	46,567	5,097	51,029	5,585	56,317	6,164
BRAINTREE	29,610	2,239	30,319	2,293	32,148	2,431	34,411	2,602
SOMERVILLE	20,136	2,061	22,494	2,302	25,886	2,650	27,385	2,803
REVERE	8,176	1,228	8,803	1,322	9,314	1,399	9,953	1,495
MEDFORD	19,513	1,175	19,734	1,188	22,311	1,343	25,225	1,519
MALDEN	19,076	782	17,873	733	19,452	797	21,836	895
MILTON	5,128	691	5,720	771	6,293	848	6,978	940
Subtotal	307,771	41,281	330,928	44,428	359,062	47,962	390,384	51,864
Commuter Rail Service Area Current and Under Construction)								
WALTHAM	63,087	4,981	64,950	5,128	67,920	5,363	71,983	5,683
DEDHAM	14,050	2,504	14,631	2,608	15,668	2,792	16,975	3,025
NORWOOD	22,927	1,950	25,811	2,195	28,821	2,451	32,257	2,744
NEEDHAM	18,449	1,775	17,699	1,703	18,432	1,773	19,093	1,837
WELLESLEY	18,203	1,415	18,635	1,449	20,316	1,579	21,532	1,674
WOBURN	35,608	1,312	39,436	1,453	41,076	1,513	43,076	1,587
LYNN	29,682	1,275	26,036	1,118	25,573	1,098	25,357	1,089
CHELSEA	9,670	1,245	11,548	1,487	12,501	1,609	13,035	1,678
FRAMINGHAM	39,047	1,084	42,055	1,168	43,608	1,211	44,978	1,249
CANTON	19,068	1,034	19,909	1,080	21,375	1,159	23,090	1,252
WESTWOOD	9,157	845	9,204	849	9,522	879	9,954	919
NATICK	19,331	841	23,533	1,024	25,521	1,110	27,872	1,213
RANDOLPH	9,692	696	9,169	658	9,676	695	10,304	740
BROCKTON	38,584	610	36,575	578	35,920	568	35,758	565
STOUGHTON	13,192	583	13,682	605	14,393	636	14,893	658
WILMINGTON	19,771	442	21,583	483	22,789	509	24,186	541
BELMONT	6,877	430	5,764	360	5,861	366	6,040	378
WEYMOUTH	14,653	363	16,593	411	17,771	440	19,227	476
SALEM	20,191	345	18,365	314	18,812	321	19,435	332
CONCORD	11,643	325	13,425	375	14,549	406	15,985	446
WAKEFIELD	10,904	317	14,772	429	16,034	466	17,555	510
LOWELL	40,116	298	33,062	246	33,336	248	33,596	250
ANDOVER	24,873	287	31,766	367	34,122	394	36,883	426
SHARON	2,882	282	3,355	328	3,577	350	3,851	377
READING	6,060	271	7,303	327	8,138	364	8,695	389
WALPOLE	7,598	245	10,090	325	10,578	341	11,184	361
BILLERICA	20,009	239	25,909	309	31,844	380	34,636	414
WESTON	2,928	232	2,848	226	2,953	234	3,092	245
WESTBOROUGH	18,036	223	23,518	291	25,248	312	27,801	344
BEVERLY	15,406	190	17,082	211	18,261	225	19,926	246
WINCHESTER	6,729	175	7,493	195	8,204	213	9,049	235
GLOUCESTER	11,268	174	11,528	178	11,455	177	11,521	178

Table B-1 - Projected Employment of Boston Residents by EMRPP City or Town
(Unconstrained by Boston Population Growth)

Employment Location	1990 Employment		2000 Employment (est.)		2010 Employment (est.)		2020 Employment (est.)	
	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.
Commuter Rail Service Area Current and Under Construction (continued)								
ACTON	9,395	157	10,318	172	11,334	189	11,908	199
MELROSE	6,082	144	6,506	154	7,081	168	7,774	184
MANSFIELD	8,771	143	10,963	179	12,093	197	13,222	216
LAWRENCE	23,417	139	21,147	126	21,173	126	21,241	126
BRIDGEWATER	5,061	116	6,915	158	7,638	175	8,415	193
LITTLETON	5,342	99	5,279	98	7,922	147	8,248	153
FRANKLIN	7,156	96	10,814	145	11,628	156	12,375	166
HALIFAX	683	86	998	126	1,147	144	1,306	164
LINCOLN	1,671	81	1,668	81	1,743	84	1,843	89
HOLBROOK	3,035	75	2,743	68	2,865	71	3,017	75
NORFOLK	2,373	72	3,394	103	3,904	118	4,284	130
PLYMOUTH	16,066	70	18,804	82	19,984	87	21,346	93
SOUTHBOROUGH	4,097	67	5,540	91	6,285	103	6,768	111
ATTLEBORO	21,561	58	23,251	63	23,827	64	24,631	66
IPSWICH	3,082	57	3,792	70	4,033	75	4,318	80
KINGSTON	4,656	53	5,633	64	6,287	72	6,843	78
ABINGTON	3,306	44	3,975	53	4,196	56	4,353	58
NEWBURYPORT	8,256	42	10,153	52	11,649	59	12,796	65
ASHLAND	4,075	41	4,240	43	4,547	46	4,881	49
MANCHESTER	1,266	34	1,528	41	1,653	44	1,787	48
HANSON	1,706	33	1,913	37	2,109	41	2,294	44
WHITMAN	2,843	32	2,984	34	3,064	34	3,185	36
HAVERHILL	17,378	30	18,955	33	19,579	34	20,563	35
AYER	6,149	24	5,112	20	5,650	22	6,016	23
SWAMPSCOTT	2,747	22	3,327	27	3,473	28	3,667	29
LAKEVILLE	1,940	20	2,718	28	3,663	38	4,088	42
WENHAM	661	18	1,235	34	1,343	37	1,471	40
MIDDLEBOROUGH	6,612	13	7,359	14	9,130	18	11,066	22
ROWLEY	1,446	7	2,137	10	2,529	12	2,923	14
HAMILTON	1,237	0	1,379	0	1,460	0	1,516	0
SHIRLEY	1,120	0	1,746	0	1,817	0	1,892	0
ROCKPORT	1,344	0	1,425	0	1,483	0	1,537	0
Subtotal	784,225	28,861	845,280	30,679	900,143	32,631	954,393	34,688
Commuter Rail Service Area (Planned Expansion)								
HINGHAM	9,730	410	11,078	467	11,581	488	12,226	515
TAUNTON	19,882	145	22,301	163	24,976	182	27,974	204
EASTON	5,855	105	8,397	151	9,794	176	10,980	197
SCITUATE	2,906	59	3,161	64	3,337	68	3,560	72
COHASSET	2,024	24	1,994	24	2,058	24	2,148	25
RAYNHAM	4,503	11	7,117	17	8,462	21	9,808	24
Subtotal	44,900	754	54,048	885	60,208	959	66,696	1,038

Table B-1 - Projected Employment of Boston Residents by EMRPP City or Town
(Unconstrained by Boston Population Growth)

Employment Location	1990 Employment		2000 Employment (est.)		2010 Employment (est.)		2020 Employment (est.)	
	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.
Other EMRPP Communities (Closer to Rapid Transit)								
WATERTOWN	17,178	2,708	17,744	2,797	18,016	2,840	18,500	2,916
BURLINGTON	33,103	1,185	36,297	1,299	38,356	1,373	40,055	1,434
LEXINGTON	19,411	861	21,009	932	21,608	958	22,720	1,008
ARLINGTON	9,153	729	9,100	725	9,694	772	10,434	831
BEDFORD	24,620	573	19,938	464	23,451	546	25,174	586
EVERETT	12,086	556	9,994	460	12,073	555	14,058	647
WINTHROP	2,986	459	3,008	462	3,313	509	3,651	561
SAUGUS	9,875	429	10,946	476	11,801	513	12,789	556
Subtotal	128,412	7,500	128,036	7,615	138,312	8,067	147,381	8,538
Other EMRPP Communities (Closer to Commuter Rail)								
MARLBOROUGH	20,531	556	27,071	733	33,638	911	38,016	1,030
PEABODY	21,692	384	26,164	463	29,635	525	32,614	577
DANVERS	22,291	311	21,367	298	21,863	305	22,628	316
STONEHAM	8,107	305	8,788	331	9,485	357	10,051	378
WAYLAND	3,286	290	3,200	282	3,455	305	3,740	330
SUDBURY	9,706	186	6,591	126	7,639	146	8,472	162
CHELMSFORD	15,065	171	20,248	230	24,527	278	26,852	305
MARSHFIELD	4,201	164	4,671	182	4,995	195	5,381	210
TEWKSBURY	9,489	163	17,932	308	21,696	373	23,952	411
HOPKINTON	3,900	140	7,683	276	8,792	316	9,869	354
HANOVER	6,569	140	6,378	136	6,576	140	6,849	146
MARBLEHEAD	4,498	134	5,023	150	5,339	159	5,736	171
FOXBOROUGH	8,506	130	9,148	140	9,628	147	10,018	153
HUDSON	8,381	121	10,116	146	11,291	163	12,089	175
MEDFIELD	3,509	110	3,692	116	3,826	120	3,972	125
NORTH ANDOVER	16,758	102	19,355	118	20,858	127	21,813	133
AVON	4,975	101	6,804	138	8,429	171	8,759	178
MAYNARD	7,403	98	4,673	62	4,559	60	4,484	59
LYNNFIELD	3,337	97	4,980	145	5,672	165	6,109	178
WEST BRIDGEWATER	4,922	93	7,950	150	8,410	159	8,749	165
MILFORD	11,181	90	12,614	102	13,547	109	14,607	118
NORWELL	5,511	88	9,167	146	11,434	183	12,814	205
WRENTHAM	4,268	87	4,147	85	4,562	93	4,746	97
MILLIS	2,124	67	2,244	71	2,326	73	2,445	77
NORTH ATTLEBOROUGH	8,851	63	12,320	88	14,370	102	15,855	113
ROCKLAND	6,643	63	8,276	78	9,526	90	10,567	100
DOVER	620	61	898	88	1,019	100	1,128	111
METHUEN	13,482	54	12,115	49	12,505	50	13,047	52
DUXBURY	2,256	52	2,546	59	2,740	63	2,938	68
NORTH READING	3,454	51	5,609	83	6,640	98	7,394	109
HULL	1,085	47	1,207	52	1,219	53	1,241	54
WESTFORD	5,565	43	8,875	69	10,471	81	12,202	94
HOLLISTON	4,209	43	4,808	49	5,162	53	5,576	57

Table B-1 - Projected Employment of Boston Residents by EMRPP City or Town
(Unconstrained by Boston Population Growth)

Employment Location	1990 Employment		2000 Employment (est.)		2010 Employment (est.)		2020 Employment (est.)	
	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.
Other EMRPP Communities (Closer to Commuter Rail) (continued)								
TOPSFIELD	1,779	40	2,753	62	3,172	71	3,549	80
HARVARD	1,004	40	1,118	45	1,288	51	1,414	56
BOXBOROUGH	2,286	39	2,227	38	6,404	109	6,469	110
PEMBROKE	3,832	37	4,772	46	5,488	53	6,174	60
NAHANT	496	36	409	30	412	30	416	30
DRACUT	4,113	35	4,438	38	4,678	40	4,963	42
NORTHBOROUGH	6,109	34	6,310	35	6,690	37	7,177	40
CARLISLE	649	33	817	42	848	43	888	45
MEDWAY	1,796	31	2,380	41	2,605	45	2,852	49
CLINTON	4,658	27	4,763	28	4,715	27	4,693	27
AMESBURY	4,399	23	4,829	25	5,010	26	5,242	27
STOW	2,260	20	2,118	19	2,221	20	2,346	21
NORTON	4,066	18	5,846	26	6,876	30	7,932	35
MIDDLETON	2,489	18	4,743	34	5,053	37	5,419	39
BELLINGHAM	2,949	17	4,522	26	5,435	31	6,259	36
ESSEX	1,089	16	1,354	20	1,484	22	1,628	24
GEORGETOWN	1,483	13	2,240	20	2,594	23	2,898	25
MENDON	879	13	1,388	21	1,593	24	1,790	26
GROTON	2,739	11	2,675	11	2,753	11	2,858	11
TYNGSBOROUGH	2,320	8	3,991	14	4,900	17	5,748	20
NEWBURY	914	7	959	7	1,106	8	1,271	10
BOXFORD	695	6	831	7	917	8	997	9
BOLTON	1,471	5	2,394	8	2,927	10	3,496	12
NORTHBRIDGE	3,082	0	4,200	0	5,017	0	5,418	0
CARVER	1,299	0	1,998	0	2,649	0	3,154	0
SALISBURY	1,995	0	2,746	0	3,073	0	3,390	0
LANCASTER	2,269	0	2,785	0	2,983	0	3,219	0
UXBRIDGE	1,982	0	2,463	0	2,652	0	2,870	0
GROVELAND	822	0	1,107	0	1,201	0	1,270	0
PEPPERELL	1,358	0	1,596	0	1,676	0	1,746	0
MERRIMAC	718	0	924	0	1,004	0	1,090	0
BERLIN	398	0	594	0	650	0	716	0
HOPEDALE	1,526	0	1,602	0	1,705	0	1,825	0
WEST NEWBURY	502	0	684	0	739	0	798	0
UPTON	915	0	1,008	0	1,072	0	1,121	0
PLAINVILLE	3,041	0	2,715	0	2,915	0	3,215	0
DUNSTABLE	161	0	231	0	254	0	280	0
MILLVILLE	111	0	195	0	208	0	229	0
SHERBORN	551	0	553	0	589	0	617	0
EAST BRIDGEWATER	3,377	0	3,031	0	3,193	0	3,385	0
BLACKSTONE	907	0	796	0	836	0	885	0
PLYMPTON	481	0	244	0	260	0	275	0
Subtotal	336,345	5,132	404,009	6,188	457,679	7,044	496,695	7,646
Total EMRPP AREA	2,139,317	272,699	2,327,387	288,615	2,527,878	312,154	2,716,779	336,421

Table B-2 - Projected Employment of Boston Residents by EMRPP City or Town
(Constrained by Boston Population Growth)

Employment Location	1990 Employment		2000 Employment (est.)		2010 Employment (est.)		2020 Employment (est.)	
	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.
CITY OF BOSTON	537,664	189,171	565,086	192,715	612,474	202,557	661,230	207,306
Rapid Transit Service Area								
CAMBRIDGE	103,278	16,039	114,144	17,182	124,536	18,179	137,245	18,993
NEWTON	44,793	7,300	47,768	7,546	49,751	7,621	52,062	7,560
BROOKLINE	18,123	5,395	17,506	5,051	18,342	5,132	18,972	5,033
QUINCY	39,938	4,371	46,567	4,940	51,029	5,250	56,317	5,492
BRAINTREE	29,610	2,239	30,319	2,222	32,148	2,285	34,411	2,319
SOMERVILLE	20,136	2,061	22,494	2,232	25,886	2,490	27,385	2,498
REVERE	8,176	1,228	8,803	1,282	9,314	1,315	9,953	1,332
MEDFORD	19,513	1,175	19,734	1,152	22,311	1,263	25,225	1,354
MALDEN	19,076	782	17,873	710	19,452	750	21,836	798
MILTON	5,128	691	5,720	747	6,293	797	6,978	838
Subtotal	307,771	41,281	330,928	43,064	359,062	45,083	390,384	46,215
Commuter Rail Service Area Current and Under Construction)								
WALTHAM	63,087	4,981	64,950	4,971	67,920	5,041	71,983	5,064
DEDHAM	14,050	2,504	14,631	2,527	15,668	2,625	16,975	2,696
NORWOOD	22,927	1,950	25,811	2,128	28,821	2,304	32,257	2,445
NEEDHAM	18,449	1,775	17,699	1,651	18,432	1,667	19,093	1,637
WELLESLEY	18,203	1,415	18,635	1,404	20,316	1,484	21,532	1,491
WOBURN	35,608	1,312	39,436	1,408	41,076	1,423	43,076	1,414
LYNN	29,682	1,275	26,036	1,084	25,573	1,033	25,357	971
CHELSEA	9,670	1,245	11,548	1,441	12,501	1,513	13,035	1,495
FRAMINGHAM	39,047	1,084	42,055	1,132	43,608	1,138	44,978	1,113
CANTON	19,068	1,034	19,909	1,046	21,375	1,090	23,090	1,116
WESTWOOD	9,157	845	9,204	823	9,522	826	9,954	818
NATICK	19,331	841	23,533	992	25,521	1,044	27,872	1,081
RANDOLPH	9,692	696	9,169	638	9,676	653	10,304	659
BROCKTON	38,584	610	36,575	560	35,920	534	35,758	504
STOUGHTON	13,192	583	13,682	586	14,393	598	14,893	586
WILMINGTON	19,771	442	21,583	468	22,789	479	24,186	482
BELMONT	6,877	430	5,764	349	5,861	344	6,040	337
WEYMOUTH	14,653	363	16,593	398	17,771	414	19,227	424
SALEM	20,191	345	18,365	304	18,812	302	19,435	296
CONCORD	11,643	325	13,425	363	14,549	382	15,985	398
WAKEFIELD	10,904	317	14,772	416	16,034	438	17,555	455
LOWELL	40,116	298	33,062	238	33,336	233	33,596	222
ANDOVER	24,873	287	31,766	355	34,122	370	36,883	379
SHARON	2,882	282	3,355	318	3,577	329	3,851	336
READING	6,060	271	7,303	317	8,138	342	8,695	346
WALPOLE	7,598	245	10,090	315	10,578	321	11,184	321
BILLERICA	20,009	239	25,909	300	31,844	358	34,636	369
WESTON	2,928	232	2,848	219	2,953	220	3,092	218
WESTBOROUGH	18,036	223	23,518	282	25,248	293	27,801	306
BEVERLY	15,406	190	17,082	204	18,261	212	19,926	219
WINCHESTER	6,729	175	7,493	189	8,204	201	9,049	210
GLOUCESTER	11,268	174	11,528	173	11,455	166	11,521	159

Table B-2 - Projected Employment of Boston Residents by EMRPP City or Town
(Constrained by Boston Population Growth)

Employment Location	1990 Employment		2000 Employment (est.)		2010 Employment (est.)		2020 Employment (est.)	
	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.
Commuter Rail Service Area Current and Under Construction (continued)								
ACTON	9,395	157	10,318	149	11,334	158	11,908	164
MELROSE	6,082	144	6,506	149	7,081	158	7,774	164
MANSFIELD	8,771	143	10,963	173	12,093	185	13,222	192
LAWRENCE	23,417	139	21,147	122	21,173	118	21,241	112
BRIDGEWATER	5,061	116	6,915	154	7,638	165	8,415	172
LITTLETON	5,342	99	5,279	95	7,922	138	8,248	136
FRANKLIN	7,156	96	10,814	141	11,628	147	12,375	148
HALIFAX	683	86	998	122	1,147	136	1,306	147
LINCOLN	1,671	81	1,668	78	1,743	79	1,843	80
HOLBROOK	3,035	75	2,743	66	2,865	67	3,017	66
NORFOLK	2,373	72	3,394	100	3,904	111	4,284	116
PLYMOUTH	16,066	70	18,804	79	19,984	82	21,346	83
SOUTHBOROUGH	4,097	67	5,540	88	6,285	97	6,768	99
ATTLEBORO	21,561	58	23,251	61	23,827	60	24,631	59
IPSWICH	3,082	57	3,792	68	4,033	70	4,318	71
KINGSTON	4,656	53	5,633	62	6,287	67	6,843	69
ABINGTON	3,306	44	3,975	51	4,196	52	4,353	52
NEWBURYPORT	8,256	42	10,153	50	11,649	56	12,796	58
ASHLAND	4,075	41	4,240	41	4,547	43	4,881	44
MANCHESTER	1,266	34	1,528	40	1,653	42	1,787	43
HANSON	1,706	33	1,913	36	2,109	38	2,294	40
WHITMAN	2,843	32	2,984	33	3,064	32	3,185	32
HAVERHILL	17,378	30	18,955	32	19,579	32	20,563	32
AYER	6,149	24	5,112	19	5,650	21	6,016	21
SWAMPSCOTT	2,747	22	3,327	26	3,473	26	3,667	26
LAKEVILLE	1,940	20	2,718	27	3,663	35	4,088	38
WENHAM	661	18	1,235	33	1,343	34	1,471	36
MIDDLEBOROUGH	6,612	13	7,359	14	9,130	17	11,066	19
ROWLEY	1,446	7	2,137	10	2,529	12	2,923	13
HAMILTON	1,237	0	1,379	0	1,460	0	1,516	0
SHIRLEY	1,120	0	1,746	0	1,817	0	1,892	0
ROCKPORT	1,344	0	1,425	0	1,483	0	1,537	0
Subtotal	784,225	28,861	845,280	29,720	900,143	30,652	954,393	30,897
Commuter Rail Service Area (Planned Expansion)								
HINGHAM	9,730	410	11,078	452	11,581	459	12,226	459
TAUNTON	19,882	145	22,301	158	24,976	171	27,974	182
EASTON	5,855	105	8,397	146	9,794	165	10,980	175
SCITUATE	2,906	59	3,161	62	3,337	64	3,560	64
COHASSET	2,024	24	1,994	23	2,058	23	2,148	23
RAYNHAM	4,503	11	7,117	17	8,462	19	9,808	21
Subtotal	44,900	754	54,048	858	60,208	901	66,696	925

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Employment Location	1990 Employment		2000 Employment (est.)		2010 Employment (est.)		2020 Employment (est.)	
	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.
Other EMRPP Communities (Closer to Rapid Transit)								
WATERTOWN	17,178	2,708	17,744	2,711	18,016	2,670	18,500	2,599
BURLINGTON	33,103	1,185	36,297	1,259	38,356	1,291	40,055	1,278
LEXINGTON	19,411	861	21,009	903	21,608	901	22,720	898
ARLINGTON	9,153	729	9,100	703	9,694	726	10,434	741
BEDFORD	24,620	573	19,938	450	23,451	513	25,174	522
EVERETT	12,086	556	9,994	446	12,073	522	14,058	576
WINTHROP	2,986	459	3,008	448	3,313	479	3,651	500
SAUGUS	9,875	429	10,946	461	11,801	482	12,789	495
Subtotal	128,412	7,500	128,036	7,381	138,312	7,583	147,381	7,608
Other EMRPP Communities (Closer to Commuter Rail)								
MARLBOROUGH	20,531	556	27,071	711	33,638	856	38,016	917
PEABODY	21,692	384	26,164	449	29,635	493	32,614	514
DANVERS	22,291	311	21,367	289	21,863	287	22,628	281
STONEHAM	8,107	305	8,788	320	9,485	335	10,051	337
WAYLAND	3,286	290	3,200	274	3,455	287	3,740	294
SUDBURY	9,706	186	6,591	122	7,639	138	8,472	145
CHELMSFORD	15,065	171	20,248	223	24,527	262	26,852	272
MARSHFIELD	4,201	164	4,671	177	4,995	183	5,381	187
TEWKSBURY	9,489	163	17,932	299	21,696	350	23,952	367
HOPKINTON	3,900	140	7,683	267	8,792	297	9,869	316
HANOVER	6,569	140	6,378	132	6,576	132	6,849	130
MARBLEHEAD	4,498	134	5,023	145	5,339	150	5,736	152
FOXBOROUGH	8,506	130	9,148	136	9,628	138	10,018	136
HUDSON	8,381	121	10,116	142	11,291	153	12,089	156
MEDFIELD	3,509	110	3,692	112	3,826	113	3,972	111
NORTH ANDOVER	16,758	102	19,355	114	20,858	119	21,813	118
AVON	4,975	101	6,804	134	8,429	161	8,759	158
MAYNARD	7,403	98	4,673	60	4,559	57	4,484	53
LYNNFIELD	3,337	97	4,980	140	5,672	155	6,109	158
WEST BRIDGEWATER	4,922	93	7,950	146	8,410	149	8,749	147
MILFORD	11,181	90	12,614	98	13,547	102	14,607	105
NORWELL	5,511	88	9,167	142	11,434	172	12,814	182
WRENTHAM	4,268	87	4,147	82	4,562	87	4,746	86
MILLIS	2,124	67	2,244	69	2,326	69	2,445	69
NORTH ATTLEBOROUGH	8,851	63	12,320	85	14,370	96	15,855	101
ROCKLAND	6,643	63	8,276	76	9,526	85	10,567	89
DOVER	620	61	898	86	1,019	94	1,128	99
METHUEN	13,482	54	12,115	47	12,505	47	13,047	47
DUXBURY	2,256	52	2,546	57	2,740	59	2,938	60
NORTH READING	3,454	51	5,609	80	6,640	92	7,394	97
HULL	1,085	47	1,207	51	1,219	50	1,241	48
WESTFORD	5,565	43	8,875	66	10,471	76	12,202	84
HOLLISTON	4,209	43	4,808	48	5,162	50	5,576	51

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Employment Location	1990 Employment		2000 Employment (est.)		2010 Employment (est.)		2020 Employment (est.)	
	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.	Total	Boston Res.
Other EMRPP Communities (Closer to Commuter Rail) (continued)								
TOPSFIELD	1,779	40	2,753	60	3,172	67	3,549	71
HARVARD	1,004	40	1,118	43	1,288	48	1,414	50
BOXBOROUGH	2,286	39	2,227	37	6,404	103	6,469	98
PEMBROKE	3,832	37	4,772	45	5,488	50	6,174	53
NAHANT	496	36	409	29	412	28	416	27
DRACUT	4,113	35	4,438	37	4,678	37	4,963	38
NORTHBOROUGH	6,109	34	6,310	34	6,690	35	7,177	36
CARLISLE	649	33	817	40	848	41	888	40
MEDWAY	1,796	31	2,380	40	2,605	42	2,852	44
CLINTON	4,658	27	4,763	27	4,715	26	4,693	24
AMESBURY	4,399	23	4,829	24	5,010	25	5,242	24
STOW	2,260	20	2,118	18	2,221	18	2,346	18
NORTON	4,066	18	5,846	25	6,876	29	7,932	31
MIDDLETON	2,489	18	4,743	33	5,053	34	5,419	35
BELLINGHAM	2,949	17	4,522	25	5,435	29	6,259	32
ESSEX	1,089	16	1,354	19	1,484	20	1,628	21
GEORGETOWN	1,483	13	2,240	19	2,594	21	2,898	23
MENDON	879	13	1,388	20	1,593	22	1,790	24
GROTON	2,739	11	2,675	10	2,753	10	2,858	10
TYNGSBOROUGH	2,320	8	3,991	13	4,900	16	5,748	18
NEWBURY	914	7	959	7	1,106	8	1,271	9
BOXFORD	695	6	831	7	917	7	997	8
BOLTON	1,471	5	2,394	8	2,927	9	3,496	11
NORTHBRIDGE	3,082	0	4,200	0	5,017	0	5,418	0
CARVER	1,299	0	1,998	0	2,649	0	3,154	0
SALISBURY	1,995	0	2,746	0	3,073	0	3,390	0
LANCASTER	2,269	0	2,785	0	2,983	0	3,219	0
UXBRIDGE	1,982	0	2,463	0	2,652	0	2,870	0
GROVELAND	822	0	1,107	0	1,201	0	1,270	0
PEPPERELL	1,358	0	1,596	0	1,676	0	1,746	0
MERRIMAC	718	0	924	0	1,004	0	1,090	0
BERLIN	398	0	594	0	650	0	716	0
HOPEDALE	1,526	0	1,602	0	1,705	0	1,825	0
WEST NEWBURY	502	0	684	0	739	0	798	0
UPTON	915	0	1,008	0	1,072	0	1,121	0
PLAINVILLE	3,041	0	2,715	0	2,915	0	3,215	0
DUNSTABLE	161	0	231	0	254	0	280	0
MILLVILLE	111	0	195	0	208	0	229	0
SHERBORN	551	0	553	0	589	0	617	0
EAST BRIDGEWATER	3,377	0	3,031	0	3,193	0	3,385	0
BLACKSTONE	907	0	796	0	836	0	885	0
PLYMPTON	481	0	244	0	260	0	275	0
Subtotal	336,345	5,132	404,009	5,998	457,679	6,621	496,695	6,813
Total EMRPP AREA	2,139,317	272,699	2,327,387	279,737	2,527,878	293,396	2,716,779	299,765